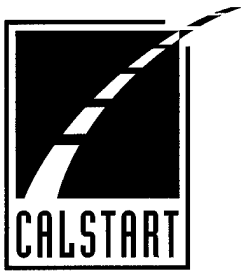

A California Non-Profit Consortium Developing Advanced Transportation Technologies

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

ELECTRIC AND HYBRID ELECTRIC VEHICLE TECHNOLOGIES

COOPERATIVE AGREEMENT MDA972-93-1-0027

QUARTERLY REPORT
April 1 to June 30, 1998

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SIX MILITARY AND NINE COMMERCIAL EV'S

Project Manager: U. S. Electricar
CS-AR93-01

The program goal is to evaluate and determine the effectiveness of U.S. Electricar electric vehicles in commercial and military applications

There was not substantial progress made on this program during this quarter. The vehicles continue to be used but U.S. Electricar did not install and data acquisition or air-conditioning systems.

Mile No.	MILESTONES	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	MATCH FUNDS EXPENDED	DARPA FUNDS EXPENDED
1	(15) Vehicles using AC-drive systems/vehicles tested.	181,000	425,000	1	7/15/93			181,000
2	Re-engineering to improve performance/vehicle testing	181,000	425,000	2	10/15/93	12/7/93		181,000
3	Data acquisition system selected/evaluation, development	181,000	425,000	3	1/15/94	12/31/93		181,000
4	Schedule retrofit program	91,000	213,000	4	4/15/94	3/2/95	**1,402,916**	91,000
5	Delivery of vehicles	91,000	213,000	5	7/15/94			23,000
6	Final report							
		725,000	**1,701,000**				**1,402,916**	**657,000**

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SMART CHARGING KIOSKS

Project Manager: HUGHES/LADWP
CS-AR93-03

The goal of the project is the development of electric vehicle infrastructure for a variety of purposes. The project will gather energy consumption on a variety of charging techniques, including inductive and conductive charging. It will also seek to develop a billing system for electric vehicle charging.

The project is completed early, but a final has not yet been submitted construction on the Kiosks was completed, CALSTART expects to include the final report in its next quarterly report to DARPA. As reported previously, the charging units at Edwards Air Force Base, the Bay Area Rapid Transit District (BART) Walnut Creek station and the South Coast Air Quality Management District (SQAMD) headquarters are all operational.

The User Interface Module (UIM) that would have allowed for Data gathering on individual vehicle charging, including power consumption and billing information has been disconnected at the BART and SCAQMD sites. UIM were not planned for the Edwards Air Force Base chargers. While the UIM functioned as designed, users of the charging kiosks routinely would not follow the charging procedures, causing the UIM to lock out all other potential users. In using the UIM to start charging, individuals would need to insert a key card to begin the charging process. The UIM was designed so that when the key card was re-inserted, the charging process would be shut down. Users rarely re-inserted the key card after completing the charging process- that caused others to be locked out.

SMART CHARGING KIOSKS

Project Manager: HUGHES/LADWP
CS-AR93-03

A complete rewrite of the software governing the use of the UIM would be necessary to solve this problem. Hughes personnel made several attempts to rework the UIM software to no avail. Since Hughes had limited interest in commercializing this product this sub-recipient was unwilling to provide match funding.

Mile No.	MILESTONES	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	MATCH FUNDS EXPENDED	DARPA FUNDS EXPENDED
	HUGHES							
1	Fabricate platform for charging units	71,850	71,850	1	10/15/93	10/93		71,850
2	Test 2 kiosks	71,850	71,850	2	1/15/94	6/94		71,850
3	Fabricate modules	109,300	109,300	3	4/15/94	6/94		109,300
4	Provide communications hardware and software	196,800	22,000	4	7/15/94	9/27/94		196,800
5	Final check out/report	60,200		5	10/15/94			
		510,000	**275,000**				**360,000**	**449,800**
	LADWP							
1	Install AQMD	27,000	189,312	1	7/15/96	6/97		
2	Final report	3,000	67,979	2	10/15/96			
		30,000	**257,291**					

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S. F. BAY AREA ELECTRIC STATION CAR DEMONSTRATION

Project Manager: Bay Area Rapid Transit
CS-AR93-05

The goal of this project is to demonstrate the viability of testing electric vehicles in a station car application

Bill Meuer, President of Green Motorworks, made a poster presentation on the results of the San Francisco Bay Area Electric Station Car Demonstration at the May 1-4, 1998, DARPA Bi-annual Review in Pasadena, California. Despite significant delays in the completion of the project, the overall San Francisco Bay Area Station Car Demonstration is a success. The complete final report is attached to this report summary. The goal of the project was to deploy 45 highway capable electric cars in a demonstration of the station car concept. While only 40 non-highway certified vehicles were deployed, the project did effectively demonstrate the Station Car concept, as detailed in the final report and below.

PIVCO of Norway delivered a total of 40 Citibee 2-seat electric vehicles for use in the project. A maximum of 38 were deployed in the demonstration project at any one time. The initial eight vehicles were delivered in December 1998. PIVCO had delivered all the vehicles by March 1997. Figure 8 on page 22 of the final report details the delivery and use schedule of the vehicles involved in this program.

During the demonstration, the station cars were driven 154,802 miles and resulted in the elimination of an estimated 16,572 internal combustion engine-powered vehicle trips, more than 94 persons participated in the demonstration by driving the Citibees. This figure does not included times when the vehicles were used as pool cars by other drivers or were leased on a short-term basis to persons not in the program. Table 6 on page 27 of the final report details the total vehicle miles traveled by vehicle and includes average monthly mileage for each vehicle.

S. F. BAY AREA ELECTRIC STATION CAR DEMONSTRATION

Project Manager: Bay Area Rapid Transit
CS-AR93-05

BART estimates that as a result of the availability of the station cars, passenger miles traveled on BART increased by 125,222 miles, resulting in approximately $18,464 in additional fare revenue. Extrapolating data gathered from this demonstration, a program with 10,000 station cars could add $32.8 million in BART fare revenues. Furthermore, using station cars could free up valuable real estate at BART stations that is currently used for individual parking (station cars can be parked in cues, thus taking considerably less space than privately owned cars parked in individual stalls).

A total of 39 charging ports were installed at four separate BART stations: Ashby (Berkeley), Lake Merritt (Oakland), Walnut Creek and Colma. An additional 19 chargers were installed at Sybase, a company in Berkeley that participated in the project for nine months. The PIVCO vehicles in the demonstration used an average of 0.36 kilowatt hours per mile traveled. No significant problems with the vehicle recharging infrastructure were encountered. However, the User Interface Module (UIM) for the chargers at the Walnut Creek BART Station was not usable, thus no detailed data on individual vehicle charging was gathered. See the Smart Charging Kiosks (CS-AR93-03) report for more information on the UIM.

Drivers in the demonstration project participated either because they were fascinated with electric vehicles or because they believed the program benefited the environment. More Participants also appreciated having convenient access to mass transit as well as zero maintenance requirements for the vehicle (Green Motorworks performed all maintenance). Drivers were truly supportive of the project. In fact, the most effective method of recruiting new drivers for the program was by word-of-mouth from current drivers. Drivers in the program praised the station car concept and the Citibee vehicles, despite, particularly early in the program experiencing regular mechanical problems with the vehicle (detailed in the final report).

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S. F. BAY AREA ELECTRIC STATION CAR DEMONSTRATION

Project Manager: Bay Area Rapid Transit
CS-AR93-05

A significant amount of general public and media attention was garnered by the project. Many drivers indicated frequent encounters with persons interested in finding out more information on electric vehicles and being generally impressed with the concept of a zero-emission vehicle. The media coverage of the project is detailed on pages 12 and 13 of the final report. While the benefits of general public interest and media attention are not readily quantifiable, it does serve to illustrate the important role this project played in demonstrating that electric vehicles are available and usable today.

This project provided a demonstration of a novel concept with first-of-its-kind, preproduction, purpose-built electric vehicles. The project participants believe the demonstration program to be a success. However, several recommendations for additional demonstrations of station cars and electric vehicles were made. Project participants indicate that future station car demonstrations should include better vehicle tracking and communication software, and incorporate instant rental/access technology. Furthermore, a variety of problems with the PIVCO vehicles were identified, as expected with preproduction vehicles. During the course of the project, PIVCO worked with Green Motorworks to identify and solve these problems. As a result, PIVCO has launched its next generation of the Citibee-type vehicle. DARPA deserves significant praise for exercising patience with this program and waiting for the successes to occur. As a result of this program, PIVCO has expressed considerable interest in manufacturing an electric vehicle at former Alameda Naval Air Station. CALSTART will continue to monitor the progress of PIVCO and the station car program.

The final payment will be made to BART next quarter.

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S. F. BAY AREA ELECTRIC STATION CAR DEMONSTRATION

Project Manager: Bay Area Rapid Transit
CS-AR93-05

MI NO	MILESTONES	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	MATCH FUNDS EXPENDED	DARPA FUNDS EXPENDED
1	BART will lease or purchase 45 highway capable cars	0	75,000	1	7/15/93			
2	Assemble operating/repair manuals. Safety certify cars	0	200,000	2	10/15/93			
3	Develop reporting standard	146,000	200,000	3	1/15/94	8/17/94		146,000
4	Develop battery re-cycling process	146,000	200,000	4	4/15/94	1/31/96		146,000
5	Final report	146,000	200,000	5	7/15/94			
	TOTAL	**438,000**	**875,000**				**1,120,259**	**292,000**

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DATA ACQUISITION

Project Manager: CALSTART
CS-AR93-10

The goal of this program is to develop and demonstrate a data acquisition system for electric and hybrid electric vehicles.

As previously reported, independent development of a data acquisition system was halted when it was realized that the system cost would exceed that of other available systems. There were no significant developments to report this quarter. The following is the status of the vehicles that we will be collecting data from:

AVS Bus w/Capstone Turbine: Advanced Vehicle Systems continues to obtain data from Capstone that will be provided to DARPA via the SCAT consortium.

ISE Hybrid Electric Prototype Truck: Not yet operational. Completion has been pushed back to August. ISE is continuing development of a special on-board diagnostic system to gather data while the vehicle is in service.

UC Davis Hybrid Electric Vehicle w/Moller Rotary Engine as APU: Operational but Moller is having trouble with the Bolder Batteries. If the battery situation can be resolved, Moller will begin collecting data.

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DATA ACQUISITION

Project Manager: CALSTART

CS-AR93-10

Mi. No	MILESTONES	DARPA	MATCH	DATE DUE	DATE COMPLETE	MATCH FUNDS EXPENDED	DARPA FUNDS EXPENDED
1	Written Summary of DAS Vehicle Specs Definition of test	13,000		7/15/93	8/1/93		13,000
2	System Selection Sensor package Installation	7,000		10/15/93	12/31/93		7,000
3	Work w/companies to establish data collection process	6,000		1/15/94			6,000
3	Data Collection	6,000		4/15/94			6,000
3	Data Collection	6,000		7/15/94			6,000
3	Data Collection	6,000		10/15/94			6,000
3	Data Collection			1/15/95			
3	Data Collection			4/15/95	TBD		
4	Final report						
		44,000	**0**				**44,000**

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HYBRID BUS DEMONSTRATION

Project Manager: ***Santa Barbara Air Pollution Control District***
CS-AR93-12

The goal of this program is to deploy two of CNG hybrid-electric buses in regular service. The program includes the conversion of a Gillig Phantom to CNG hybrid-electric drive as well as a purpose-built CNG hybrid-electric bus from APS Systems. Both vehicles are full size heavy-duty transit buses.

APS 40 Foot CNG Hybrid Electric Transit Bus (Purpose Built)

APS has completed construction of the bus and is making final adjustments. CALSTART Program Manager John Tripp and representatives from the Santa Barbara Air Pollution Control District (SBAPCD) test rode the bus (on electric power only) on June 4, 1998. The bus performed extremely well during the test drive. However, the auxiliary power unit (APU) was not operating smoothly at the time and still needs further adjustments at Cummins Cal-Pacific. AVS will send the bus to Cummins during July for necessary APU adjustments. APS currently projects bus completion on August 1, 1998. It is expected that the bus will be delivered to and generated in for service by Santa Barbara Metropolitan Transportation District.

BMI/Gillig Hybrid Electric Transit Bus (Conversion)

Gillig delivered the bus to Bus Manufacturing, Incorporated (BMI) at McClellan Air Force Base in Sacramento on April 7, 1998. BMI conducted testing and debugged various technical problems with consultation from both Gillig and local Sacramento Municipal Utility District personnel. SBAPCD requested that BMI test bus performance at McClellan for reporting purposes prior to delivery of the bus to Golden Gate Transit. During the next quarter, a bus demonstration agreement with Golden Gate Transit will be drafted. Work will also continue on following up with Gillig on the outstanding deliverables, including bus documents, drawings and an operator's manual.

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HYBRID BUS DEMONSTRATION

Project Manager: ***Santa Barbara Air Pollution Control District***
CS-AR93-12

Recent performance testing has shown the bus to be inadequate for its intended transit duty cycle at Golden Gate Transit. BMI sent a status report on July 2, 1998, detailing the situation, which is attached. The problem appears to be in the combination of the Horizon batteries with the chosen APU. SBAPCD has recommended that the final project report include technical/test data on the bus and recommendations for improving bus performance. CALSTART is working to resolve this issue with SBAPCD, BMI, Gillig and Golden Gate Transit. CALSTART and SBAPCD have discussed obtaining the performance data from the testing at McClellan to include in the program final report due in August.

Mi. No	MILESTONES	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	MATCH FUNDS EXPENDED	DARPA FUNDS EXPENDED
1	Assemble technical advisory team, procure components	51,000	195,000	1	1/15/94	12/31/93		227,000
2	Field operation/data collection	176,000	195,000	2	4/15/94	7/22/94		176,000
3	Review data	176,000	195,000	3	7/15/94	1/4/96		125,000
4	Document retrofit process	125,000	145,000	4	10/15/94			
5	Final report	125,000	145,000	5	1/15/95			
		653,000	**875,000**				**714,455**	**528,000**

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PROGRAM MANAGEMENT

Project Manager: ***CALSTART***
CS-AR93-99

The program goal is to effectively manage the research and development programs in the DARPA RA-93 program.

CALSTART continues to work with the project participants to bring closure to this overall research and development grant. It is expected that all of the projects will be closed out next quarter. CALSTART intends to submit final reports for the remaining projects next quarter.

Mi. No	MILESTONES	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	DARPA FUNDS EXPENDED
	Program management	75,000			7/15/93		75,000
	Program management	75,000			10/15/93		75,000
	Program management	75,000			1/15/94		75,000
	Program management	75,000			4/15/94		75,000
	Program management	75,000			7/15/94		75,000
	Program management	75,000			10/15/94		75,000
	Program management	75,000			1/15/95		75,000
	Program management	75,000			4/15/95		75,000
		600,000	**0**				**600,000**

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APPENDIX

DARPA FINANCIAL REPORT FORMAT

FY	Proj.No	PROJECT TITLE		Mod. No.	DARPA	MATCH	QTR	DATE DUE	DATE COMPLETE	DARPA FUNDS EXPENDED	NOTES
93	CS-AR93-01	6 Military and 9 Commercial EVs US Electricar			725,000	1,701,000	X	07/15/94		657,000	Program delayed due to US Electricar's financial problems. USE still intending to complete program.
93	CS-AR93-02	Military/Commercial EV's	AECT		93,000	125,000	X	07/15/94	03/29/96	93,000	Closed Out
93	CS-AR93-03	Smart Charging Kiosks	Hughes		510,000	275,000	X	10/15/94		449,800	Program delayed. Kiosks will be completed in FY97.
93	CS-AR93-03	Smart Charging Kiosks	LADWP		30,000	257,291	X	10/15/96			Program delayed. Both kiosks will be installed in FY97.
93	CS-AR93-04	Seven Kewet Electric Vehicles Green Motorworks			74,000	72,000	X	10/15/93	12/06/93	74,000	Closed Out
93	CS-AR93-05	45 Electric Station Cars	BART		438,000	875,000	X	07/15/94		292,000	Program delayed. 40 cars now in use.
93	CS-AR93-06	Running Chassis	Amerigon		601,000	1,160,000	X	01/15/94	03/15/94	601,000	Closed Out
93	CS-AR93-07	Minority Outreach	PSE		50,000	50,000	X	01/15/95	01/31/95	50,000	Closed Out
93	CS-AR93-08	Internship	CAL State		50,000	45,000	X	01/15/95	06/29/95	50,000	Closed Out
93	CS-AR93-09	Environmental Study	NRDC		50,000	50,000	X	07/15/94	01/28/95	50,000	Closed Out
93	CS-AR93-10	Data Acquisition	CALSTART		44,000					44,000	In Progress
93	CS-AR93-12	Hybrid Bus Demonstration	SBAPCD		653,000	875,000	X	01/15/95		528,000	Delays encountered. Buses still to be completed.
93	CS-AR93-99	Program Management	CALSTART		682,000					682,000	
93 Total					**4,000,000**	**5,485,291**				**3,570,800**	
Grand Total					**4,000,000**	**5,485,291**				**3,570,800**	

FY	Proj. No	Mile. No.	PROJECT TITLE AND NUMBER	DARPA	MATCHING	QTR	DATE DUE	DATE COMPLETE	DARPA FUNDS EXPENDED	NOTES
93	CS-AR93-01	1	(3) vehicles using AC-drive systems/vehicles tested.	181,000	425,000	1	7/15/93		181,000	
93	CS-AR93-01	2	Re-engineering to improve performance/vehicle testing	181,000	425,000	2	10/15/93	12/7/93	181,000	
93	CS-AR93-01	3	Data acquisition system selected/evaluation, development	181,000	425,000	3	1/15/94	12/31/93	181,000	
93	CS-AR93-01	4	Schedule retrofit program	91,000	213,000	4	4/15/94	3/2/95	94,750	All 15 Vehicles Delivered.
93	CS-AR93-01	5	Delivery of vehicles	91,000	213,000	5	7/15/94		19,250	
	CS-AR93-01 Total			725,000	1,701,000				657,000	
93	CS-AR93-02	1	Convert (3) military S-10 trucks to electric propulsion	31,000	31,000	1	7/15/93	9/30/93		
93	CS-AR93-02	2	Provide SCAQMD with seven vehicles	31,000	31,000	2	10/15/93		62,000	
93	CS-AR93-02	3	Provide Operating manual/telephone service to assist repair	31,000	31,000	3	1/15/94		31,000	
93	CS-AR93-02	4	DOT crash test certification in compliance with FMVSS requirements	0	16,000	4	4/15/94			
93	CS-AR93-02	5	Maintenance/repair log and repair data		16,000	5	7/15/94			
	CS-AR93-02 Total			93,000	125,000				93,000	
93	CS-AR93-03A	1	Fabricate platform for charging units	71,850	71,850	1	10/15/93	Oct-93	71,850	
93	CS-AR93-03A	2	Test 2 kiosks	71,850	71,850	2	1/15/94	Jun-94	71,850	
93	CS-AR93-03A	3	Fabricate modules	109,300	109,300	3	4/15/94	Jun-94	109,300	
93	CS-AR93-03A	4	Provide communications hardware and software	196,800	22,000	4	7/15/94	Sep-94	196,800	
93	CS-AR93-03A	5	Final check out/report	60,200		5	10/15/94			
	CS-AR93-03A Total			510,000	275,000				449,800	
93	CS-AR93-03B	1	Install AQMD	27,000	189,312	1	7/15/96	Jun-97		
93	CS-AR93-03B	2	Final report	3,000	67,979	2	10/15/96			Utilities delayed in completing program due to bureaucratic issues.
	CS-AR93-03B Total			30,000	257,291				0	

FY	Proj. No	Mile. No.	PROJECT TITLE AND NUMBER	DARPA	MATCHING	QTR	DATE DUE	DATE COMPLETE	DARPA FUNDS EXPENDED	NOTES
93	CS-AR93-04	1	Provide vehicles: Pasadena/Chula Vista/Alhambra/UC Davis	34,000	30,000	1	7/15/93	9/21/93	34,000	Management Plan complete 8/27/93.
93	CS-AR93-04	2	Provide manuals/diagrams/supply parts and log repairs and maintenance	40,000	42,000	2	10/15/93	12/10/93	40,000	Rpt 12/6/93 - vehicles delivered.
	CS-AR93-04 Total			74,000	72,000				74,000	
93	CS-AR93-05	1	BART will lease or purchase 45 highway capable cars	0	75,000	1	7/15/93			
93	CS-AR93-05	2	Assemble operating/repair manuals. Safety certify cars	0	200,000	2	10/15/93			
93	CS-AR93-05	3	Develop reporting standard	146,000	200,000	3	1/15/94			
93	CS-AR93-05	4	Develop battery re-cycling process	146,000	200,000	4	4/15/94	3/17/94	146,000	
93	CS-AR93-05	5	Final report	146,000	200,000	5	7/15/94	1/31/96	146,000	
	CS-AR93-05 Total			438,000	875,000				292,000	
93	CS-AR93-06	1	Management plan	201,000	660,000	1	7/15/93	11/16/93	200,000	
93	CS-AR93-06	2	Test components: Motor, Aluminum Frame, Energy Mgmt System, Regenerative Braking, HVAC	200,000	300,000	2	10/15/93	11/16/93	200,000	
93	CS-AR93-06	3	Deliver prototype & additional units	140,000	200,000	3	1/15/94	3/8/94	140,000	
93	CS-AR93-06	4	Final Report	60,000		4		6/30/94	61,000	**Closed Out**
	CS-AR93-06 Total			601,000	1,160,000				601,000	
93	CS-AR93-07	1	Information and database development	10,000	10,000	1	7/15/93			
93	CS-AR93-07	2	Continued development of MBE outreach program	7,000	7,000	2	10/15/93	12/7/93	17,000	
93	CS-AR93-07	3	Outreach to various organizations	6,000	6,000	3	1/15/94	2/15/94	6,000	
93	CS-AR93-07	4	Development of MBE database/outreach	6,000	6,000	4	4/15/94	6/15/94	6,000	
93	CS-AR93-07	5	Final task for MBE symposium/MBE database	6,000	6,000	5	7/15/94	8/17/94	6,000	
93	CS-AR93-07	6	Database complete, referrals to minority organizations	5,000	5,000	6	10/15/94	11/2/94	5,000	
93	CS-AR93-07	7	Final report	10,000	10,000	7	1/15/95	6/16/95	10,000	
	CS-AR93-07 Total			50,000	50,000				50,000	

FY	Proj. No	Mile. No.	PROJECT TITLE AND NUMBER	DARPA	MATCHING	QTR	DATE DUE	DATE COMPLETE	DARPA FUNDS EXPENDED	NOTES
93	CS-AR93-08	1	Management plan	8,000	8,000	1	7/15/93			
93	CS-AR93-08	2	Establish 4 intern placements	7,000	7,000	2	10/15/93			
93	CS-AR93-08	3	Define mentors/Submit resumes	6,000	5,000	3	1/15/94			Placed Interns
93	CS-AR93-08	4	Interns working	6,000	5,000	4	4/15/94			
93	CS-AR93-08	5	Enrichment activities	6,000	5,000	5	7/15/94	7/21/94	33,000	
93	CS-AR93-08	6	Further enrichments/Summer plan	6,000	5,000	6	10/15/94	1/17/95	6,000	
93	CS-AR93-08	7	Final report	11,000	10,000	8	1/15/95	3/2/95	11,000	
	CS-AR93-08 Total			50,000	45,000				50,000	
93	CS-AR93-09	1	Management plan	12,000	12,000	1	7/15/93			
93	CS-AR93-09	2	Report on study progress	12,000	12,000	2	10/15/93			
93	CS-AR93-09	3	Completed study	12,000	12,000	3	1/15/94			Finalized 1st draft of EV report.
93	CS-AR93-09	4	Distribution of material	7,000	7,000	4	4/15/94			
93	CS-AR93-09	5	Final report	7,000	7,000	5	7/15/94		50,000	Study/Qrtly reports submitted 1/28/95.
	CS-AR93-09 Total			50,000	50,000				50,000	
93	CS-AR93-10	1	No Milestone, data acquisition	44,000					44,000	
	CS-AR93-10 Total			44,000	0				44,000	
93	CS-AR93-12	1	Assemble technical advisory team, procure components	51,000	195,000	1	1/15/94			
93	CS-AR93-12	2	Field operation/data collection	176,000	195,000	2	4/15/94		227,000	
93	CS-AR93-12	3	Review data	176,000	195,000	3	7/15/94			
93	CS-AR93-12	4	Document retrofit process	125,000	145,000	4	10/15/94	1/4/95	125,000	
93	CS-AR93-12	5	Final report	125,000	145,000	5	1/15/95	7/22/95	176,000	
	CS-AR93-12 Total			653,000	875,000				528,000	
93	CS-AR93-99	1	No Milestone, program management	682,000					682,000	
	CS-AR93-99 Total			682,000	0				983,000	
93 Total				4,000,000	5,485,291				3,570,800	
	Grand Total			**4,000,000**	**5,485,291**				**3,570,800**	

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Cooperative Agreement MDA972-93-1-0027
Quarterly Report
April 1 to June 30, 1998

APPENDIX

Bay Area Rapid Transit Final Report

SAN FRANCISCO BAY AREA STATION CAR DEMONSTRATION:

EVALUATION REPORT

Prepared by the National Station Car Association
www.stncar.com
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June 30, 1998

With Contributions by
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Funded and Published by the Bay Area Rapid Transit District (BART)
Oakland, California

ACRONYM LIST

APTA.....American Public Transit Association

BAAQMD.....Bay Area Air Quality Management District

BART.....Bay Area Rapid Transit District

BofA.....Bank of America

CALSTART.....a California organization created to support advanced transportation technology industries and markets

CEC.....California Energy Commission

CO_2.....carbon dioxide

DARPA.....Defense Advanced Research Projects Agency, U.S. Department of Defense

DMV .....California Department of Motor Vehicles

EPRI.....Electric Power Research Institute

EV.....battery-powered electric vehicle

EV1.....General Motors' sports EV

EVS-14.....Electric Vehicle Symposium 14

FMVSS.....U.S. Federal Motor Vehicle Safety Standards

FTE.....full-time equivalent

GMW.....Green Motorworks, Inc.

ICE .....internal combustion engine (car)

ITS.....Intelligent transportation systems

kWh .....kilowatt hour

MOU.....memorandum of understanding

NO_x.....nitrogen oxides

NSCA .....National Station Car Association

PG&E .....Pacific Gas and Electric Company

PIVCO .....Personal Independent Vehicle Company, manufacturer of the City Bee

pmt .....passenger miles of travel

ROG .....reactive organic gases

TAC .....Technical Advisory Committee

TOD.....transit-oriented development

US DOT.....U.S. Department of Transportation

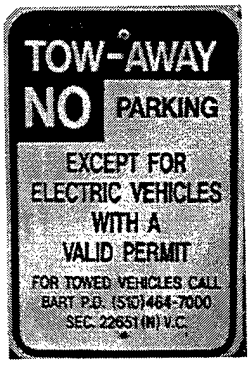
vmt.....vehicle miles of travel

EXECUTIVE SUMMARY

The San Francisco Bay Area Station Car Demonstration was a preliminary test of a larger vision of solving several problems associated with line-haul mass transit (rail, ferry, and possibly express bus), in general, and the Bay Area Rapid Transit District (BART), in particular. Except for downtown stations, stations are surrounded by huge parking facilities, isolating the station from the surrounding community and limiting pedestrian access. The need to park conventional cars in a conventional manner near a station limits transit-oriented development opportunities. As this report shows, the station car concept directly addresses reducing the requirement that prime land near the station be dedicated to inefficient, static parking. The concept also offers the opportunity for transit to better serve the ever-growing number of suburban work sites, thereby increasing patronage by reverse commuters. The main air-quality benefit of using electric vehicle (EV) technology as station cars is to eliminate cold starts and the first hard acceleration onto a freeway, the two events when most tailpipe emissions occur with conventional cars.

A station car in the future will be a small car driven from home to a mass transit station in the morning by a commuter, then driven from the station by a commuter to a work site where it is used as a pool car during the day. In the evening it is driven back to the station and taken home by a returning commuter. For EVs, "quick charging" will be available at homes, transit stations, and work sites. The ultimate vision is to have thousands of station cars parked in queues at BART stations. The service would be operated by a private-sector vendor at a profit. The use of queues and the fact that the cars do not spend much time at a station allow a fraction of current parking acreage to serve current and additional patrons.

The Demonstration was a field test with many components: an alliance between a transit agency and a utility; use of prototype EV technology; charging and infrastructure installation; multi-source funding; selection and training of users; many different types of participants; car sharing logistics; liability issues; billing and collecting user fees; service and maintenance support; data acquisition; and regional goals for air quality and congestion management. In short, it was a rugged field experiment with many variables. It succeeded, as described in this report, while providing many lessons that will benefit BART and others.



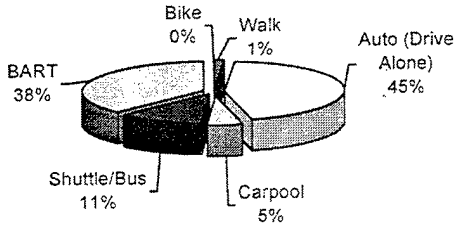
The purpose of the Demonstration was to determine the viability of EVs for making short, everyday trips in a variety of settings: between home and BART station; between BART station and work site; and pool cars used at work sites. Other short trips were encouraged during the workday or during evenings and weekends when the cars were at participants' homes. The station cars were used by a mix of public and private organizations and individuals. Participants were recruited from BART, Pacific Gas & Electric Company (PG&E), two corporations—Sybase and Bank of America (BofA), and the general public.

Planning for the Demonstration began in 1992. BART was the lead agency. Total funding was $1.486 million as follows:

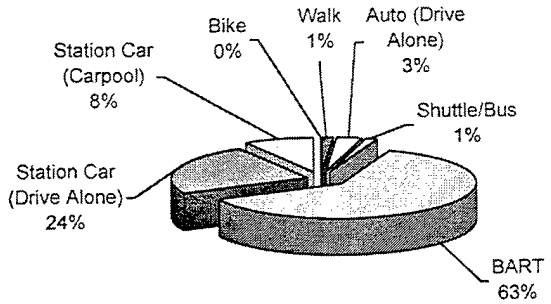
Bay Area Air Quality Management District	$700,000
Defense Advanced Research Projects Agency via CALSTART	$521,000
Pacific Gas and Electric	$100,000
California Energy Commission	$90,000
Bay Area Rapid Transit District	$75,000

The station car was a two-seat CITI prototype battery-powered EV made by the Norwegian firm, Personal Independent Vehicle Company (PIVCO). Charging ports were installed at selected BART stations. BART and PG&E jointly designed and installed the infrastructure. The turnkey service provider was Green Motorworks, Inc. (GMW), an EV dealership located in North Hollywood, California, with field staff in the Bay Area for the Demonstration. GMW provided the CITIs, vehicle maintenance, insurance, road service, interaction with the participants, and vehicle data.

Between November 1995 and March 1998, 94 people participated in the Demonstration, including two-person carpools, but not counting midday users at work sites. In addition, some cars were used as pool cars or, when vehicles were available, leased on a short-term basis to people not in the program. Assuming that many spouses and housemates also used the EVs, well over 200 people experienced driving the CITIs.



Modal Split Without Demonstration



Modal Split With Demonstration

During the Demonstration, the station cars were driven 154,802 vehicle miles of travel (vmt) and produced 179,470 passenger miles of travel (pmt). For the participants, internal combustion engine (ICE) automobile pmt decreased 94%. There would have been 16,572 ICE automobile trips, mainly on freeways, without the Demonstration. With the Demonstration, there were only 3,083 ICE automobile trips and most of these were short to access BART on the home end when a station car was used on the work end. BART pmt for the participants increased by 125,222 (56%) because of the Demonstration. In fares, this represented approximately $18,464 in increased revenue. Carpooling actually increased because it was encouraged for participation in the Demonstration. There

would have been 11 carpools without the Demonstration and there were 24 carpools with it.

Due to the changed travel patterns of the participants, emissions of reactive organic gases, nitrogen oxides, and carbon dioxide were reduced 93.5%, 98.0%, and 90.0%, respectively. The average kWh/mi for the CITIs was 0.34.

Based on data from the Demonstration, a scenario of 10,000 station cars in the Bay Area was constructed to show the positive impacts that a large-scale deployment of station cars could have. In terms of BART fares, the scenario adds $32.8 million annually. The scenario shows that the station car concept could have the potential of improving the transportation-related problems in the Bay Area during the first decade of the next century, especially if it is extended to the other Bay Area rail systems, ferries, and some express bus routes.

The Demonstration produced many non-quantifiable effects, many of which may be more important than the quantifiable ones. During the Demonstration, the station cars dripped no gasoline, crankcase oil, transmission fluid, or coolant onto streets and parking places, which would eventually drain to the San Francisco Bay. Socially and educationally, the station cars were important. Because of broad exposure, extensive national and international press coverage, and their visibility on a daily basis in the Bay Area, possibly millions of people learned that small EVs are real, are here today, and are providing pollution-free transportation. This awareness will encourage people to explore owning an EV when the option is presented to them. It will no doubt help the EV industry sell/lease EVs. It will help the local economy if, as planned, the EV industry establishes manufacturing in the Bay Area.

It is clear that people who displayed interest in the Demonstration were true innovators. People participated either because they were fascinated by EVs and EV technology or because they believed the program benefited the environment, which fit in with their personal value systems. The average length of participation among the general public during the 12 months when they could join was 6.7 months (they could sign up for three-month periods). The people in the program longest were Bank of America employees for 19.5 months.

Drivers rated the relative importance of benefits and limitations of EVs and the Demonstration while in the program. It is not surprising that environmental benefits are highly rated, but "no vehicle maintenance" came in third—higher than "more convenient mass transit" (a major reason given before entering the program), which tied with "not stopping at gas stations."

While in the program, participants were queried about their interest in continuing to use station cars at the home-end, work-end, and both. Opinions were correlated to how respondents used their station cars. *All* of the home-end users would continue to use station cars at the home end, but only 36% would want them also at the work end; 90% of the work-end users would use station cars at the home end and 60% would continue use at the work end. The primary reasons for continuing were convenience, a good commute, good for the environment, and "love the car."

People who were sent contracts, but did not sign and return them, were contacted to learn their reasons, including sensitivity to the lease rate. The four major reasons were that it cost too much, the CITI was too small, the CITI could not be driven on the freeway, and their circumstances had changed.

Among the challenges facing station-car and car-sharing programs that use EVs rather than gasoline-fueled cars is recruiting participants who fit the programs' "profile," determining the appropriate fee/lease structure, and meeting drivers' needs within the limitations of the program's infrastructure. Recruitment of participants from BART, PG&E, Sybase, and BofA was coordinated within each organization by someone assigned to the task. Four methods of marketing the station cars were tested to determine which one (or which combination) was most successful in recruiting participants from the general public: (1) neighborhood newspaper ads; (2) displaying the vehicles at highly trafficked places; (3) flyers at BART stations; and (4) one-on-one contacts via e-mail, phone numbers on vehicles, word-of-mouth, and television news items. In the end, the most effective method was the fourth—an indication of the importance of finding true innovators who will act as ambassadors and influence others' decisions to participate.

While participants were still driving the CITIs, they were asked what they would be willing to pay for a station car at the home-end, the work-end, and both home- and work-ends. They were also given the American Automobile Association's estimate for the fully-loaded monthly cost of owning a vehicle, which was $450. Five groups emerged: those who wouldn't pay more than $100 per month; a group that was willing to pay $100; those willing to pay $200; a group that varied its willingness-to-pay between $100 and $200; and a fifth group that valued station cars at around $300. Willingness-to-pay to continue using a station car was compared to current lease amounts. In all cases where two people shared the lease amount, they were willing to pay as much as an additional $200 per month (splitting the cost). The majority of respondents were happy with the current lease amount, with over half wishing to continue at the same or slightly higher level. Again, there were two groups at both tails of the curve, willing to pay either considerably more or considerably less.

A willingness-to-pay issue to address in future demonstrations, and more systematically through research, is the perceived difference between the station car as a "product" and as a "service." When perceived as a product, the potential user considers a monthly leasing cost over a long period of time; when perceived as a service, the potential user considers a daily—or even hourly—cost.

A most important conclusion is that the Demonstration took BART and others far along the station-car learning curve. It has been the starting point for demonstrations elsewhere and set the stage for more complex multiple-user demonstrations as the next step in commercializing the concept.

The Demonstration had many non-quantifiable positive benefits. The response from the drivers and the general public was clear—people "love" the idea and "love" small functional EVs. From transit's point of view, the increased ridership (especially in

the reverse-commute direction), increased turnover from oversubscribed parking areas, and the potential for more profitable land use may be the greatest benefits. Certainly, these will be primary goals of an expanded program.

Increased awareness of EVs by the general public, the potential impact on the EV industry, lessons learned about the evolving station-car concept, and the station-car momentum that exists within and outside BART comprise the true legacy of the Demonstration. All this exists because of 40 red, green, and blue plastic/aluminum EVs, plus the vision and dedication of all the stakeholders—a plastics company, the sponsors, the service provider, key BART staff, and two private corporations—and, of course, the participants who were out there, day after day, demonstrating the concept and showing off their EVs.

Based on this evaluation of the Demonstration, which shows the potential of the station car concept, the authors recommend that BART proceed with more complex and technically challenging demonstrations and field tests. These tests should include electronics for vehicle access by multiple users and electronics for tracking the vehicles and communicating with the drivers. Reservation and billing systems should be tested. Other participants from the mobility industry (i.e., car makers, rental car agencies, and electronics firms) should be invited to participate in and contribute to these tests. In addition, market research is needed to determine how and where station car use can be maximized.

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SECTION 1. BACKGROUND AND OVERVIEW

The San Francisco Bay Area Station Car Demonstration was a field test with many components: an alliance between a transit agency and a utility; use of prototype electric vehicle (EV) technology; charging and infrastructure installation; multi-source funding; selection and training of users; many different types of participants; car sharing logistics; liability issues; billing and collecting user fees; service and maintenance support; data acquisition; and regional goals for air quality and congestion management. In short, it was a rugged field experiment with many variables. It succeeded, as described in this report, while providing many lessons that will benefit others.

Definitions

In this demonstration, a station car was a two-seat CITI prototype battery-powered EV made by the Norwegian firm, Personal Independent Vehicle Company (PIVCO).[1] Infrastructure consisted of charging ports at Bay Area Rapid Transit District (BART) stations, including the transformers and cabling necessary to connect the ports to the stations' electrical systems. BART and Pacific Gas and Electric Company (PG&E) jointly designed and installed the infrastructure. BART was the lead agency; all contracts and memoranda of understanding (MOUs) were initiated by BART. Participants were the users of the station cars—both drivers and riders. The turnkey service provider was Green Motorworks, Inc. (GMW), an EV dealership located in North Hollywood, California, with field staff in the Bay Area for the demonstration. GMW provided the 40 CITIs, vehicle maintenance, insurance, road service, interaction with the participants, and monthly vehicle data (odometer reading, kWh reading, and user for each vehicle).

Purpose of the Demonstration

The purpose of the Demonstration was to determine the viability of EVs for making short, everyday trips in a variety of settings: home to BART station ("home-end" use); station to work site ("work-end" use); and pool cars for work sites. Other short trips were encouraged during the workday or evenings and weekends when the cars were at participants' homes.

Funding

Planning for the Demonstration began in 1992. Developments throughout 1993-1994 consisted of securing funds, establishing partnerships, and soliciting bids for EVs. In 1994, BART negotiated four funding agreements totaling $1.41 million. The Bay Area Air Quality Management District (BAAQMD) granted $700,000 from

[1] A list of acronyms is provided on the inside front cover.

the Transportation Fund for Clean Air. Through CALSTART, the project received $521,000 from the Defense Advanced Research Projects Agency (DARPA) of the U.S. Department of Defense. Other contributions were $100,000 (plus in-kind assistance) from PG&E, and $90,000 from the California Energy Commission. BART contributed $75,000, plus over $240,000 of in-kind support. Total funding, then, was $1.73 million.

Field-Test Designs and Mid-Course Adjustments

The original plan was for a two-year program, with half of the 40 participants being BART employees and half being PG&E employees. Fifty to 60 ports (electrical outlets) for recharging vehicle batteries were planned for five stations.

The first major change in the Demonstration occurred early in 1995 when negotiations between U.S. Electricar (the first selected turnkey service provider) and BART were terminated. BART modified the Demonstration by finding, through CALSTART, an offshore EV manufacturer (PIVCO) willing to lease 40 CITIs (known as the "City Bee" in Europe) for two years. GMW entered a leasing agreement with PIVCO and a turnkey service provider contract with BART. Eight CITIs were delivered in September 1995 and four more in February 1996. These vehicles did not meet the U.S. Federal Motor Vehicle Safety Standards (FMVSS); the remaining 28 met more of the standards, but failed to meet them all.

The second change came when Sybase (a large computer software firm 1.5 miles from the Ashby BART station) expressed interest, through the City of Emeryville, in supporting a highly visible work-end program. As a result, 19 charging ports were installed at the Ashby BART Station. Sybase drivers started in November 1995, but the company—suffering from unrelated financial setbacks—withdrew participation in mid-August 1996. The program was then opened to BART and PG&E staff, as well as to employees of another company—Bank of America (BofA). CITIs were used for a variety of home- and work-end trips, with many driver/rider pairs. The final major programmatic change occurred in March 1997 when approval for participation by the general public was received. For the remaining year of the Demonstration, the CITIs were used by this mix of public and private organizations and individuals for work- and home-end use and as pool cars.

During the last three months of the Demonstration, two small multiple-use tests were held: (1) a two-month experiment where cars were used multiple times a day between the Lake Merritt Station and Alameda Hospital by its staff; and (2) a test with the City of Berkeley, in which home-end cars were also used during the day as work-end pool cars.

As a result of these program changes, much more was learned about day-to-day station car operations, willingness-to-pay issues, marketing, and variations in station car use.

Recharging Infrastructure

Infrastructure was installed at four BART stations: 19 charging ports at Ashby; 8 at Walnut Creek; 2 at Lake Merritt; and 10 at Colma. These facilities are described in greater detail in Section 3. BART provided the electricity for recharging at no cost to the user and parking near the entrances to the stations was guaranteed.

Participants

Between November 1995 and March 1998, 94 people participated in the Demonstration, including two-person carpools, but not counting midday users at work sites. In addition, some cars were used as pool cars or, when vehicles were available, leased on a short-term basis to people not in the program. Assuming that many spouses and housemates also used the EVs, well over 200 people experienced driving the CITIs. If exposure to the EVs were to be measured, possibly millions of people learned that EVs are *real*.

Purpose and Organization of this Report

This report is the only comprehensive evaluation of the entire Demonstration, from its inception through its official conclusion in March 1998.[2] Although other reports have analyzed "pieces" of the Demonstration (see Appendix A), the analyses in this document aggregate data for cars and participants for the entire period of operation.

This report contains the results of the process evaluation (how the program operated, changes made, monitoring data, participant descriptions and attitudes) and the impacts on energy and the environment in the following sections:

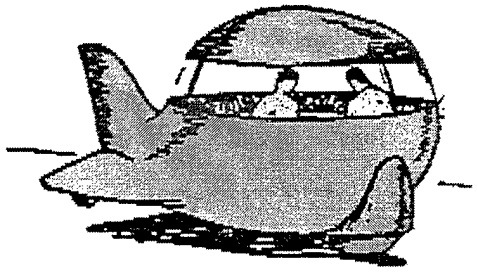
- Program Management and Issues
- Infrastructure
- Vehicles
- Environmental and Energy Impacts
- Non-Quantifiable Impacts
- Participants, including Recruitment and Marketing
- Economic Analysis
- Conclusions and Lessons Learned

[2] In 1994, the National Station Car Association (NSCA) developed an evaluation plan for use by all its members and was a guide for the analysis in this report.

SECTION 2. PROGRAM MANAGEMENT AND ISSUES

Start-up Time and Activities Leading to Program Implementation

The concept of using electric cars to access mass transit is not new. The American Planning Association found the idea in a 1940 science fiction book (see drawing in Figure 1). In the San Francisco Bay Area, the concept was studied in the 1970s (a newspaper item describing the study is excerpted in Appendix B), but nothing happened because no viable EV technology existed. In 1991, Honda R&D North America, Inc., approached PG&E about designing EVs as commuter cars and PG&E said, "Let's talk to BART." BART was receptive. PG&E and BART decided to jointly develop a "station car" demonstration.



A 1940 version of a station car drawn by architect Richard Bennett for a futuristic novel by Granville Hicks.

Figure 1. First Known Station Car Concept

The BART Planning Department took the idea to the BART general manager as one of several options for better managing the parking resources of the BART system. After some convincing, he embraced the concept. A project manager from BART R&D was asked to develop the concept with PG&E. She became the "champion" for the project—an essential requirement for every successful station car demonstration. She spent a large proportion of her time from 1992 through 1995 planning and implementing the Demonstration. As the Project Manager, she had freedom within BART to make day-to-day decisions and received significant support from many BART departments.

In 1992, other transit agencies and electric utilities were contemplating or planning station car demonstrations. In November, BART, PG&E, the Electric Power Research Institute (EPRI), other transit agencies, and electric utilities met to discuss the need for a national overview and information exchange organization. With start-up funds from EPRI, the National Station Car Association (NSCA) was formed. Initial membership was limited to transit agencies and electric utilities. Since then, some EV manufacturers have joined.

In 1992, BART and PG&E began writing grant proposals, which resulted in $1.41 million of funding for the Demonstration. BART took the active lead, while, over time, PG&E placed less programmatic emphasis on EVs, and thus put fewer resources into the Demonstration than initially envisioned.

Table 1 lists primary planning activities and dates of their execution. Key people involved during the Demonstration are listed in Appendix C.

Table 1. Demonstration Tasks

Task/Activity	Date
Concept development, planning, funding solicitations	1992 - 1993
Vendor solicitations and negotiations	March 1994 - August 1995
Infrastructure planning	May 1994 - February 1995
Infrastructure construction	July 1995 - September 1996
Walnut Creek Station kiosk installation	July 1994 - January 1997
Develop lease agreement with GMW	March – August 1995
Data acquisition decisions	On-going throughout
Station car delivery	October 1995 - August 1996
Driver selection	October 1995 - February 1998
Begin Demonstration	November 1995
End Demonstration	March 31, 1998
Final Report	June 30, 1998

Demonstration Design and Changes

On March 1, 1995, U.S. Electricar asked for major changes in the proposed contract, which were unacceptable to BART. BART was able to modify the Demonstration by finding, through CALSTART, an offshore EV manufacturer (PIVCO) willing to lease 40 CITIs for two years. GMW entered into a leasing agreement with PIVCO and a turnkey service provider contract with BART. Eight CITIs were delivered in September 1995 and four more in February 1996. These vehicles did not meet the FMVSS; the remaining 28 met more of the standards, but failed to meet them all.[3]

Sybase (a large computer software firm 1.5 miles from the Ashby Station) expressed interest, through the City of Emeryville, in supporting a highly visible work-end program, which resulted in 22 employees driving 10 station cars from the Ashby Station to work, using the cars for short trips during the day, and returning to Ashby Station in the evening. Cars were seldom used evenings or weekends. Carpooling was encouraged. Sybase was responsible for recruiting drivers, supporting a coordinator, and paying the $100/month/car leasing fee. To support this and other anticipated demand, 19 charging ports were installed in the Ashby Station parking lot.

After 10 months, in mid-August 1996, Sybase terminated participation due to financial setbacks, thus releasing these cars just as the third batch of 28 PIVCOs was arriving. Knowing that cars would be available, recruitment efforts were initiated for

[3] In the contract between PIVCO and GMW, PIVCO fully acknowledged that these were preproduction cars and reserved the right to have the cars sent back to Norway at any time without stating a reason. All 40 CITIs were waivered into the U.S. for a limited amount of time since they did not meet FMVSS. PIVCO determined that all the cars met at least the 30 mph front-barrier crash standard. When it became clear that the last batch of 28 could not meet FMVSS as expected, BART required that they meet at least the interior flammability standard. Independent engineering analysis at the time determined that the two important standards that the CITIs did not meet were the rear and static side standards. They also did not meet some minor standards; for example, they had European instead of U.S. headlights.

BART and PG&E employees. Efforts to find another private sector participant resulted in interest by BofA, focusing on employees who worked in San Francisco, but lived near the Ashby Station. BofA recruited within, and six people began driving five station cars immediately when Sybase dropped out; payment of the $150/month lease for home-end use was split 50/50 between BofA and the employee. BofA continued to be involved through the end of the Demonstration, with three more employees joining the program.

Thirteen BART (or BART contractor) employees also entered the program at this time, largely because charging/parking facilities were installed at the Colma BART Station (at the end of the line, just south of San Francisco). This enabled employees who worked eight miles further south at a BART office (used for planning the BART San Francisco Airport extension) to take BART from and to home, use station cars between the Colma Station and the work site, and have the cars for short trips during the day. The work-end lease rate was $100/month paid by the employee. Ten charging ports were installed in the parking garage just inside the Colma Station entrance.

At this point, the minimum length of the lease was set at three months. A few other BART and PG&E employees took advantage of the guaranteed parking and charging at the BART Walnut Creek Station (which has oversubscribed parking) for a $150/month home-end lease paid by the employee.

Throughout Fall 1996 and Winter 1997, the CITIs that arrived in the third batch were worked on to bring them up to mechanical readiness for leasing. They had several problems, but the main one was unreliability—the battery charger on some cars intermittently incorrectly sensed that the battery was fully charged (when it was not) and would stop charging; the dashboard indicator also incorrectly showed the battery as fully charged. This was eventually determined to be a design flaw in the BRUSA charger and was corrected. To solve this problem and keep the cars on the road, GMW hired one part-time and two full-time employees (replacing the part-time employee who had run the program since its inception, but who was not a mechanic).

Two technical factors also delayed the program. One was getting the Hughes control kiosk to work properly at the Walnut Creek Station, which has four conductive and four inductive charging ports designed to be controlled by the kiosk (similar to an ATM machine). Another delay was related to the installation of air conditioning in the eight cars scheduled for the Walnut Creek Station. One was retrofitted with air conditioning from Saab and five from Glacier Bay. The ducting in the CITIs proved insufficient to move the required amount of air, thus the retrofits were inefficient at temperatures above 80°F and their weight further reduced the performance of the cars.[4] The participants at the Walnut Creek Station preferred cars with-

[4] The installed units were a new technology designed for EVs—extremely energy efficient and thus did not reduce range significantly. Unfortunately, the task of gathering data about the impact of air conditioning on range never occurred.

out air conditioning, so the systems were removed from four of the cars. This does not mean that EVs cannot be air-conditioned—only that the retrofits were unsatisfactory.

Because of these delays and because the agreement between BAAQMD and BART stipulated that all 40 cars be operated for one full year, the Demonstration was extended six months to March 31, 1998. PIVCO agreed to provide additional funding for product liability insurance and maintenance staff to allow the Demonstration's extension.

When the reliability problem with the CITIs was finally solved in February 1997, another major change in the program was approved—leasing the cars to the general public in conjunction with using BART. This was necessary because BART and PG&E were unable to recruit 20 participants each. Up to this time, with a couple of exceptions, the cars were leased only to employees of the four previously mentioned participating organizations. But, with no marketing plan in place to reach the general public, some vehicles that were ready for participants were at times unused. To get these cars on the road, GMW rented some to non-BART riders and offered limited weekly rentals while marketing efforts were put in place.

The last changes to the program occurred between November 1997 and March 1998. Teletrac[5] systems were installed on eight CITIs. Limited communication was possible between a driver and an operator at the GMW computer. The car locks were converted to use a common key. The Teletrac installation and the ability of a pool of participants to access any of the eight cars allowed for multiple users of each car each day.

During February and March 1998, three cars were used by eight employees of Alameda Hospital. The hospital was chosen because of its large base of employees (500) and its round-the-clock rotational shifts. Prior to the Alameda Hospital field test, five of the participants drove alone between home and the hospital. During the test, they drove to the BART station nearest their home (three drove to the North Concord Station and two drove to the Dublin/Pleasanton Station), rode BART to the Lake Merritt Station, and took a station car to the hospital (four miles). Three of the participants drove the vehicles for errands from and to the hospital when they were not in use for commutes. This was a seven-days-a-week test.[6]

Beginning March 1, 1998, the City of Berkeley leased two Teletrac CITIs for use by its employees. The cars were driven to the job site by City employees arriving at the Ashby Station. During the day the cars served as pool cars. They were returned to Ashby Station in the evening. Some participants already in the Demonstration remained in the program and took seven of the cars home evenings and weekends.

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[5] Teletrac is a radio-frequency-based vehicle tracking system that allowed the computer in the GMW office in Alameda to map the location of each car and give the nearest street address.

[6] CF International set up and monitored this multiple-user demonstration under a contract with the Transportation Research Board.

These two multiple-user tests were short-term and inconclusive, mainly because the original demonstration and infrastructure was designed for single users. However, multiple-use is necessary to make the station car concept cost effective and will be the focus of subsequent demonstrations at BART. The Demonstration officially ended midnight, March 31, 1998, but 25 CITIs were kept in the Bay Area, where they were maintained and leased to the general public by GMW.

Funding

Table 2 summarizes program funding, purposes, and amounts as of October 1994. This evaluation was also funded from these dollars. BART estimated that through March 31, 1998, it provided $242,566 of in-kind services to the Demonstration.[7] Emeryville funded staff at the University of California, Berkeley under a separate budget to acquire data and do an analysis of the Sybase portion of the Demonstration.

Table 2. Demonstration Funding

Source	Purpose	Amount
BAAQMD	Support the Demonstration	$700,000
DARPA via CALSTART	Support the Demonstration	$521,000
PG&E	Install infrastructure at stations and homes	$100,000
CEC	Vehicle acquisition	$90,000
BART	Demonstration Management	$75,000
Total		**$1,486,000**

BART Staffing and Responsibilities

The main BART staff consisted of Victoria Nerenberg, Project Manager, and Mark Pfeiffer, Infrastructure Manager, with part-time staff support throughout the Demonstration. The following BART departments participated in the planning, contracting, implementation, and operation of the Demonstration:

- Office of the General Manager
- Planning, Research & Development
- Engineering
- Capital Development & Control
- Operating Budgets & Analysis
- Controller Treasurer
- Legal
- Insurance
- Contract Management
- Access Planning
- Operations
- Police

[7] This estimate does not include assistance by support departments in BART.

- Real Estate
- Customer & Performance Research
- Media & Public Affairs
- Government & Community Relations
- West Bay Extensions

PG&E provided as-needed staff support and recruited PG&E participants from its San Francisco Headquarters' Clean Air Vehicles Office and contributed technical support, mainly on infrastructure, from its Research Division in San Ramon.

Technical Advisors

The Technical Advisory Committee (TAC) for the Demonstration met as needed and was chaired by the Project Manager. Members represented the PG&E Clean Air Vehicle Office, BAAQMD, the assigned staff person from CEC, CALSTART, GMW, and the Executive Director of the NSCA. Others were invited when appropriate. The purpose of the TAC meetings was to keep the sponsors up to date and make important decisions, most of which concerned changes to the Demonstration.

Public/Private Partnerships

BART established MOUs with Sybase, BofA, and the City of Berkeley for use of the CITIs by their employees. A no-cost agreement for installation of infrastructure was established with PG&E. Other contracts were with GMW as the turnkey service provider and NSCA to collect data and conduct the process and impact evaluations of the Demonstration.

Publicity

The Demonstration generated considerable interest, resulting in many news items (television, magazines, newspapers, special interest publications) and visitors from all over the world. The inaugural festivities were attended by many dignitaries, including the King and Queen of Norway, who cut the ribbon at the Ashby Station facility (Figure 2) and presided over an elaborate reception at Sybase. A second highly significant event was the visit of U. S. Secretary of Transportation Federico Peña on February 22, 1996, shown in Figure 3.

A recommendation for future projects is to keep detailed records of these contacts because they are an important gauge of a program's impact. In lieu of precise records, the following tables offer a sense of the scope and breadth of contacts and news items. Table 3 summarizes visitors; Table 4 summarizes news items. Reports and studies are in the Bibliography in Appendix A.

Figure 2. King and Queen of Norway at Ribbon-Cutting Ceremony, Ashby BART Station

Figure 3. U.S. Secretary of Transportation Federico Peña with Project Manager, Victoria Nerenberg

Table 3. Visitors to the Demonstration

Countries represented, firms or types of firms, approximate number of people in parentheses (listed in geographic order)	Norway: the King and Queen; Electronics (3); Consulate; Industrial Attaché Denmark: Researcher (1) Sweden: Researcher (1) Netherlands: Researcher (1) Germany: Daimler-Benz (8); City of Bremen (1); TV (2) France: Renault (1); Peugeot-Citroën (2) Switzerland: Mobility Car Sharing (1) Italy: Fiat (3) United Kingdom: London (2); Electronics (2) Australia: Radio (1) Japan: Toyota (8); Japan Electric Vehicle Association (10); Japan Light Metal Association (10); Honda (6); Nissan (1) Singapore: Land Authority (3)
Political representatives (listed by hierarchy)	Office of the Vice President US Department of Transportation (DOT) Secretary, Federico Peña Senate Energy R&D Subcommittee House Science Committee House Energy and Environment Subcommittee Clean Cities Program, US Department of Energy The Volpe Center, US DOT Office of Senator Levin Office of Representative Boehlert Office of Representative Fazio
Business representatives (partial list)	Daimler-Benz Research of North America General Motors Honda R&D North America Nissan North America Toyota North America Edison Electric Institute Electric Transportation Coalition Electric Vehicle Association of the Americas Electric Power Research Institute's Transportation Advisory Committee Detroit Edison Florida Power & Light Georgia Power Los Angeles Department of Water and Power Metropolitan Atlanta Rapid Transit Authority Portland General Electric Sacramento Municipal Utility District South Coast Air Quality Management District Southern California Edison Virginia Power Company

Table 4. Publications, Presentations, and News Items

Magazine articles (source, date)	Metro Magazine, 1995 On the Ground, 1995 Tech Update, 1996 New Paradigms for Public Transit, 1996 GPS World News, 1996 Passenger Transport, 1996 Bank American, 1996 Transportation Quarterly, 1997 ITS Update, 1997 CURRENT Electric Transportation News, 1997 INNOVATION, 1997 San Francisco Business Week, 1997 ETC Fast Tracks, 1998 Diablo Magazine, 1998
Reports (source, date)	PSA Peugeot Citroën, 1996 Environment Agency of Japan, 1997 University of California-Davis, 1998
Television news	Multiple TV coverage of King and Queen of Norway, 1995 CNN Future Watch, 1996 KTVU TV, Oakland, 1997 21st Century Home Show, 1997
Papers presented	Volpe Transportation Systems Center, 1994, 1997 North America EV Infrastructure Conference, 1995, 1996 Transportation Research Board, 1995, 1997, 1998 Clean Cities Conference, 1995, 1996, 1998 California Alliance for Advanced Transportation, 1996 EVS-14, 1997; EVS-15, 1998 APTA Commuter Rail Conference, 1995

SECTION 3. INFRASTRUCTURE

The original program plan called for 44 charging ports at five BART stations. Bids for infrastructure came in at $179,000—well over budget. BART decided to reduce the number of charging ports to 39 in order to bring the cost down to $110,000. Locations of charging facilities at the Ashby, Lake Merritt, Walnut Creek, and Colma Stations are identified on the map on the back cover of this report.

When Sybase expressed interest in the program, the decision was made to install facilities at the Ashby Station. In a small side parking lot at the Ashby Station, 19 ports were installed, serving 19 existing parking stalls. This lot was chosen primarily because its small size allowed control over access and parking and because of its close proximity to the station entrance. A photo of station cars in the lot is shown in Figure 4. None of the existing parking stalls was reserved for the disabled.[8] A local power distribution center, consisting of a transformer and power panel, was installed at the edge of the parking lot and enclosed by a security fence. This design minimized voltage drop and simplified future upgrades. Although power metering was located only at the station's main power feed, provisions were made to allow for limited individual metering in the future.

Figure 4. Station Car Lot at the Ashby Station (note the transformer enclosure above the car at the left)

Electric power was provided by a special purpose-built enclosure that could charge two electric cars at either 208V or 120V receptacles. Common receptacles (NERR 6-30L and 5-5, respectively) were purposely chosen to reduce costs and to provide compatibility with other EVs. Since the CITIs required less than 15A at either voltage, the size of the electrical components was minimized to reduce costs and provide easier handling. Each charging enclosure was on a pedestal (the Lake Merritt and Colma Stations required wall mounts) and contained a light controlled by a motion sensor to provide illumination at night (see Figure 5). The enclosure was lockable to control access and the car's electric cord passed through a slot in the front bottom of the enclosure, thus the vehicle could not be unplugged without opening the enclosure. This infrastructure remained in use after the Demonstration's conclusion.

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[8] In spite of the smaller car size, the lot was not re-striped for better space utilization because increasing or decreasing the number of stalls would have required a retrofit of the entire station parking lot to meet American Disabilities Act requirements, and no funds were available for this purpose.

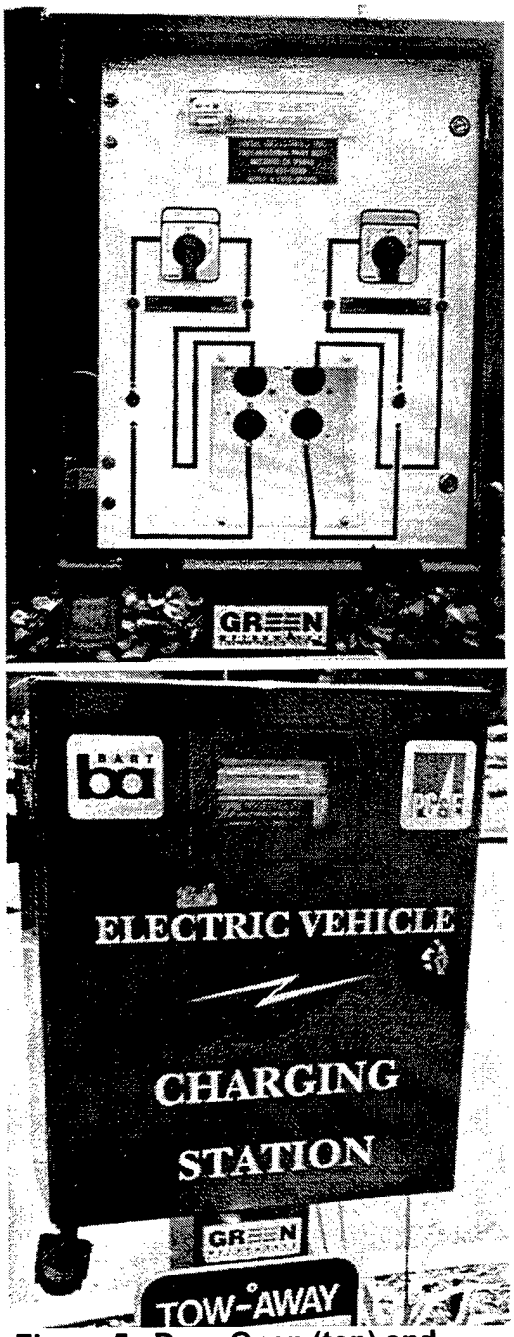

Figure 5. Door Open (top) and Closed (bottom) on a Charging Port for Two Station Cars at Ashby Station [note the sensor detecting dark and motion hanging below the cabinet that turns on the light (tube at top)]

Each car (except for the four with inductive charging) had a retractable electric cord at the front (like some vacuum cleaners) that could be pulled out and plugged into the 208V outlet. Thus, when the car was plugged in at one of the charging ports, neither end of the cord could be unplugged by a passerby.[9] For charging at home or work at 120V, each vehicle carried a short electrical cord, which converted the 240V twist-lock plug to a standard 120V plug.

Similar charging stations were installed at the Lake Merritt Station (two) and the Colma Station (10). All the charging ports at the Ashby, Lake Merritt, and Colma Stations were conductive (i.e., a physical connection, similar to plugging in a household electrical appliance). Four of the eight charging ports at the Walnut Creek Station were for conductive charging (three designs, each different than the one described above; two ports were provided by Southern California Edison, one by Sacramento Municipal Utility District, and one by Los Angeles Department of Water and Power). Four ports were for Hughes inductive charging. [For inductive charging, an alternating current (ac) passes through a primary coil of wire, which induces a current in a nearby secondary coil of wire. (Transformers work this way.) The primary coil is in a paddle (slightly smaller than a ping pong paddle, but thicker), which is inserted into a slot in the front of the car where the secondary coil is located.]

The eight ports at the Walnut Creek Station were paid for and installed by another project and are unique in several ways. First, an interface kiosk was to be used by drivers charging their vehicles at this site. The lighted mushroom-shaped enclosure had a card-reader, keypad, and monitor, similar to a typical bank ATM. Figure 6 is a photo-

[9] These installations were made before the 1997 Society of American Engineers' standards were issued about charging facilities. While they did not meet the standards, no safety related problems occurred and participants had no problems charging.

graph taken during installation. After parking, each driver could plug into a charger at the front of each parking stall, and then use a magnetic swipe card and a Personal Identification Number to communicate with the kiosk. The kiosk would verify the driver's identification, check that the car was correctly connected, and begin the charging cycle. Upon returning to the station, drivers would re-enter information at the kiosk, which would stop the power to the charger, record the total charging time, and issue a receipt if requested. In a non-demonstration situation where the user pays for the electricity, a cumulative bill would be sent monthly.

Figure 6. During the Installation of the Charging Facilities at Walnut Creek, a GM EV1 was used for Test Charging (the front of the kiosk above the car is open)

During the Demonstration, the collected data were to be studied for usage patterns and to test the reliability of the technology. Because of the different choices of charging options, it was hoped that data could be collected on driver preferences for different types of chargers. The kiosk could not be made to work consistently, it was disconnected and the ports connected directly to the power source, so these data were never collected.

In retrospect, too much infrastructure (i.e., charging ports) was installed. Depending on the station, two to five times too much infrastructure was installed. The assumption was that each car needed a charging port. The fact is that the cars spent significant time away from the stations. The Ashby Station facilities provide the best example. Nineteen charging ports and a transformer sized to supply electricity to all 19 ports at once were installed. Never were more than 12 cars assigned to Ashby Station atone time, and it is likely that never more than 6 were there at the same time. Even then, often only one was plugged in, and it was probably unusual for more than three to be plugged in at once. This is consistent with a dozen people reporting that they charged their CITIs at home anywhere from occasionally to regularly—three to four times a week.

SECTION 4. VEHICLES AND FLEET MANAGEMENT

During the Demonstration, the station cars were driven 154,802 vehicle miles of travel (vmt) and produced 179,470 passenger miles of travel (pmt). The Demonstration had 783 car months; e.g., early in the Demonstration, when the first 8 cars were being driven, each month had 8 car months.

Selection Process and Decision

The Demonstration's funding and design called for 45 two- or four-passenger electric vehicles.[10] In 1994, BART chose the bid submitted by U.S. Electricar to provide 45 converted Geo Prisms and to be the turnkey operator. However, as negotiations ensued, many problems were encountered that were not satisfactorily resolved. The major ones were:

- A crash test was not completed, resulting in non-FMVSS-certified EVs.
- The engineering of the air conditioning system was not adequate.
- The engineering of the eight cars dually-equipped with conductive charging and Hughes inductive charging was not completed.
- A systems integration problem causing the power control units to "burn out" was not resolved.
- A 20-foot extension cord that required plugging and unplugging at both ends was proposed instead of the specified retractable cord.

Negotiations fell apart March 1, 1995, when U.S. Electricar withdrew its effort to provide converted electric passenger cars, asking to supply pickup trucks instead. They may have realized they were entering into a negative financial contract and wanted to substitute less expensive vehicles. Also, they were having reliability problems with the converted EVs.

Although the Massachusetts Department of Energy Resources had a successful demonstration using converted EVs as station cars, BART's concept of station cars had developed sufficiently that conversions were far less desirable than cars built as EVs from the ground up. When U.S. Electicar dropped out, another appropriate EV was needed. Fortunately, PIVCO had been working with CALSTART since early 1994 to develop, test, and demonstrate its prototype EV in the U.S. The PIVCO CITI embodied the simple, utilitarian, functional vehicle that a station car should be. A contingent of representatives from CALSTART, GMW, and BART met with PIVCO in Oslo in June 1995 to see if PIVCO could provide vehicles for the Demonstration. An agreement was worked out for GMW to bring the CITIs into the country in batches, starting in the summer of 1995. To remain within budget, the

[10] The NSCA wrote specifications for the vehicles for proposed demonstrations throughout the country and issued a solicitation. Vendors met for a day-long meeting in Florida in February 1994. The Bay Area project received two bids—both for conventional cars converted to electric.

number of cars was reduced from 45 to 40, and the proposed cost per month per user was reduced from $200 to $150 (home-end) and to $100 (work-end) because the cars had two seats instead of four.

Fleet Management and Staff

Early discussions about station car programs in general included the options available for managing the fleet of EVs. "Managing the fleet" can be limited to vehicle maintenance or expanded to cover all aspects of interface with drivers, as well as ownership of the EVs. BART made the decision to contract with a third party to be the turnkey service provider and provide all vehicle- and participant-related services, except infrastructure. When GMW was brought in to operate the Demonstration, it was assigned the following tasks:

1. Import the cars.
2. Deploy the cars as required.
3. Train participating drivers.
4. Interact with PIVCO, which provided product liability insurance, as well as the cars.
5. Provide all licenses and registrations.
6. Maintain the CITIs.
7. Provide emergency road and towing service via a 24-hour 800 number.
8. Insure the cars for collision and comprehensive.
9. Collect monthly odometer and kWh data.
10. Handle all interactions with participants (DMV and credit background checks, proof of liability insurance, billing, and collecting user fees), except recruitment.

Throughout the Demonstration—due to the various mechanical and electrical problems with the last 28 CITIs and the fact that BART and PG&E could not recruit sufficient participants from their employees—GMW's responsibilities expanded to include:

11. Hire and train additional maintenance staff.
12. Build up and maintain an inventory of CITI parts.
13. Recruit participants.
14. Exhibit CITIs at community events (parades, etc.).
15. Meet visitors who wanted to see the Demonstration.

When the CITIs first arrived, a manager was hired part-time to interact with drivers, keep track of the cars, and troubleshoot, as necessary. GMW also hired a mechanic who did repairs on the cars as needed. Space was rented at the CALSTART

facility in a hangar at the former Alameda Naval Air Station for maintenance (shown in Figure 7). When the final batch of cars had considerable problems, the manager found that it was more than he could handle since he was not a mechanic. During the period of August 1996 to March 1997—while trying to solve the problems with the final batch of CITIs—GMW employed 3.5 full-time equivalents (FTEs) and PIVCO provided 3 FTE engineers for about 2.5 months to work on the cars.[11] After that, GMW employed 2.5 FTEs to maintain the vehicles and run the Demonstration.

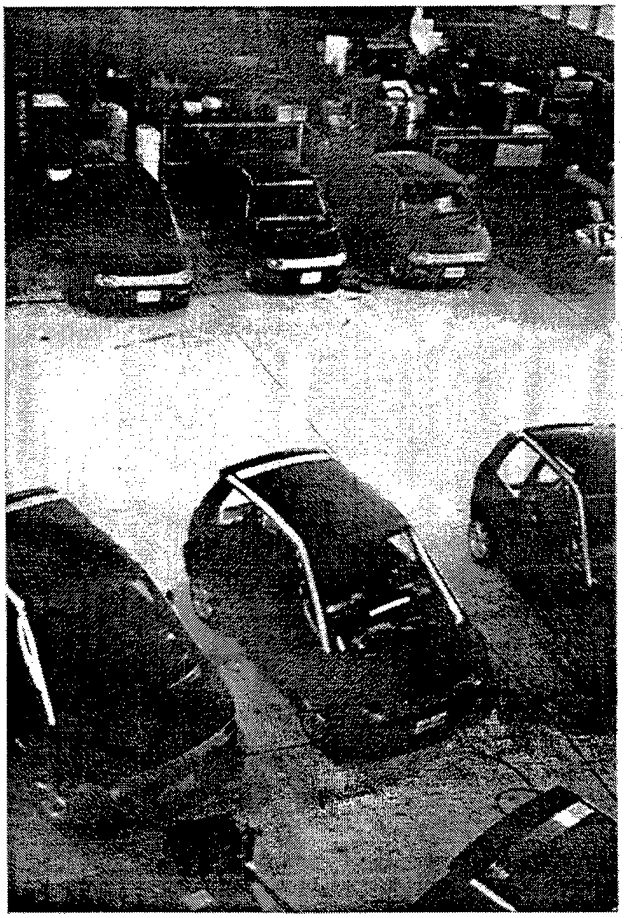

Figure 7. GMW Maintenance Facility in Alameda

Specifications, Delivery, and In-Service Schedule of the CITIs

Figure 8 illustrates the build-up of the station car fleet—when they were delivered and when they went into service. Eight cars were delivered in September 1995 and seven were put into service in November for the Sybase program (the eighth was defective, never driven, and parts were scavenged from it). The next four CITIs

[11] It was during this period that the Demonstration was almost stopped. Drivers were unhappy with unreliable cars.

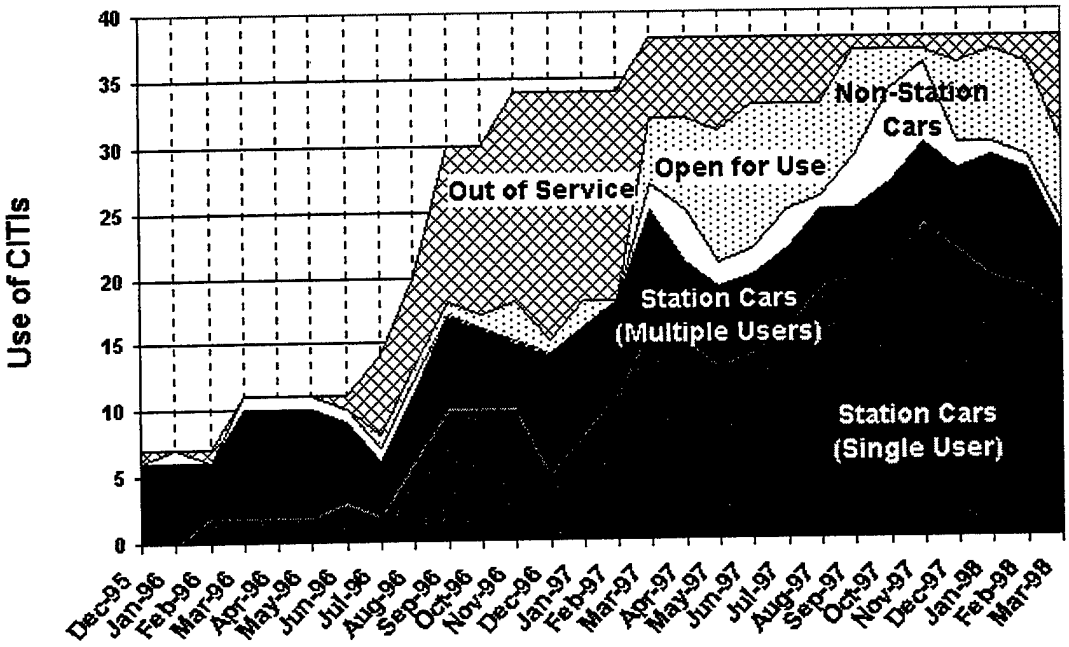

Figure 8. Monthly Status of CITIs throughout the Demonstration

were put into service in March 1996—two at Sybase, one as a pool car at BART Headquarters, and one at the CALSTART facility in Alameda (the latter was never really in station car service). The remaining 28 CITIs were delivered late in the Summer of 1996 (except for one that was defective and was later replaced by PIVCO) and were gradually put into service from August 1996 through March 1997, and from then on were available to the Demonstration. At maximum, 38 cars were available for station car service, although the maximum number of CITIs in station car use at any one time was 30 in November 1997.[12] GMW had other EVs available and in station car service, so rented some of the CITIs not in station car service to non-participants.[13] Vehicles 1 through 12 were shipped back to Norway after the March 31, 1998, end of the Demonstration. Twenty-five of the 28 in the third shipment remained in service.

Specifications for the 40 CITIs are listed in Table 5; photographs are in Figure 9.

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[12] Initially, GMW considered keeping 4 or 5 CITIs at the Alameda facility as spares (replacements for problem cars in the field); late in the Demonstration, the number of spares was reduced to two, though that still did not increase the number of cars in service.

[13] GMW continued to pursue making station cars a commercial venture after the end of the Demonstration. GMW augmented the CITIs with two EV1s, two electric Ford Escorts, six Kewets, and two Toyota RAV4-EVs. GMW proposed to BART to establish an EV rental sales kiosk at the Ashby Station where EVs could be rented by the day, week, month, or quarter.

Table 5. Specifications of the CITIs

Specifications	Vehicles 1 through 12—the 1995 PIVCO CITI Prototypes Series	Vehicles 13 through 40—the 1996 PIVCO CITI Pre-series
Colors	Red, blue, or green	Same
Body frame	Thermal plastic mass colored body, aluminum space frame, both recyclable	Same
Dimensions	5 ft wide, 5 ft high, 9.2 ft long	Same
Safety certification	European	U.S. FMVSS 1996 (Note: The cars never met all standards)
Weight	GVW rating 2,200 lb., curb weight 1,750 lb.	Same
Passenger capacity	Two	Same
Brakes	Regenerative and mechanical	Same
Steering	Rack and pinion	Same
Motor	BRUSA with AC induction, 3-phase, 2-pole, with optical encoder and peak power of 22 kW	Same
Controller	BRUSA	Same
Charger	On board 110V AC or 208V AC, 15A	Same
Batteries	120V SAFT nickel cadmium (the first 8 had 72V batteries)	120V SAFT nickel cadmium; 2 had Horizon pb/acid batteries
Charging Port	Located at front of vehicle with retractable cord	Same
Transmission	Single speed, non-shift drive	Same
Wheels/Tires	Aluminum 13" x 5", all-season steel-belted radial tires	Same
Heating/ Defrosting	1.5 kW electric	Same (2kW heaters were installed because the 1.5 kW ones were insufficient)
Radio	FM/AM	FM/AM
Top Speed	50 mph	65 mph
Range	At a constant 40 mph, 45 mi.; stop-and-go, 35 mi. (the cars could easily go 45 miles on a charge doing non-freeway urban driving)	At a constant 40 mph, 55 mi.; stop-and-go, 40 mi. (the cars were range tested in normal driving around Berkeley at 72 miles)
Acceleration	0 - 30 mph, 14 sec.; 0 - 50 mph, 25 seconds	0 - 30 mph, 9 sec.; 0 - 50 mph, 18 sec.
Charging	5 to 6 hours at 208 V; 7 to 10 hours at 110 V	4 with inductive charging, 24 with conductive
Air Conditioning	None	8 retrofitted (6 were retrofitted unsatisfactorily, 4 AC units were removed)

Figure 9. PIVCO CITIs Top to Bottom: Charging at the Ashby Station Car Facility; Charging at a Residence; Going to the Inaugural Event; On-street Parking with Space for Two in One Spot

Fleet Maintenance

Figure 8 (page 22) clearly illustrates the frequency of the problems with the vehicles, requiring considerable mechanical and electrical attention to make them reliable or to bring them in from service and make extensive repairs (the hatch-marked portion of the chart). Each car in the third batch had many problems due to changes in design that had not been tested. GMW staff were unable to handle the volume of problems, so a full-time fleet manager was hired in February 1997 to focus on getting the CITIs driveable and in use. The sharp rise in use from February to April 1997 shows how important it was to have the manager and his mechanical staff to concentrate on the fleet. Note, however, that there was a group of cars that took much longer to put on the road. This was due to the false indication that the battery was charged—a problem that was not resolved until December 1997 when it was discovered that some incorrect wiring had been installed when the cars were built.

MANAGER for electric car rental co. in Alameda. Must be self starter to manage & admin. Electric car rental prog. Gd DMV req. Fax resume

818-766-3771

Fleet maintenance turned out to be a major time-consuming activity. Also, a number of vandalism incidents occurred. Although no problems resulted in injury or negative publicity, they caused considerable inconvenience periodically for the drivers. Never-the-less, participants "loved" their the cars, as their comments presented at the end of Section 9 reflect.

Problems with the CITIs included:

- Leaking windshields and door frames
- Excessive gear noise
- Rear hatch problems requiring replacements
- Soft and questionable brakes
- Failed chargers
- Unsatisfactory radios
- Heater-defroster not clearing windows
- No safety interlock to prevent driving while charging
- No brake lights when in regenerative braking mode
- Extremely hard suspension
- Did not meet FMVSS

The final 28 cars had a manufacturing design flaw in a new dc converter system, which caused intermittent failure of the vehicle electrical system and caused the onboard charger to miscalculate the amount of charge for the batteries. Furthermore, each vehicle exhibited leakage from the top of the windshield and the four corners of the roof. PIVCO agreed to send technicians to Alameda in early 1997 to complete factory upgrades on the first 12 cars, mitigate the design flaw in the final

28, and seal the leakage points. PIVCO also agreed to pay—at no cost to the Demonstration—for a full-time technician and a part-time assistant, who both continued through the end of the Demonstration.

The data in Figure 8 (page 22) represent 783 car-months. The cars were driven 565 car-months (393, or 32.75 years, were true station car-months). Cars were waiting on parts or maintenance and were not driveable for 145 car-months. For 61 car months, cars were ready for service, but were held off the road as spares or were waiting for drivers. Thus, for 27.8% of the 783 car months, cars were not in service.

As the program came to a close, the fleet manager estimated that at least six cars had to be addressed each day. Most could be fixed on the spot, but one or two each day needed to be brought into the Alameda facility. Toward the end of the Demonstration, as the cars put on more and more miles, it was observed that, at 5,000 miles, the aluminum tended to fail at the transmission mounts.

In mid-1994, when U.S. Electricar was expected to provide the cars, BART wanted the following information collected whenever a car was brought in for maintenance or repair:

- Name of driver delivering the car
- Time and details of complaint or repair
- Location of repair site, including time and anticipated completion time
- Type of maintenance—preventive or corrective—and description
- Details of any body work required
- Battery pack ID
- Odometer reading
- Parts/components replaced and cost
- Labor hours and cost, including subcontracted work
- Comments

For the CITIs, records describing the maintenance and repairs were kept in some detail early on by GMW. These records included odometer readings, but not cost and time. As the project progressed, so much time was being spent on maintenance and repairs that GMW did not keep complete records. This was unfortunate, since it created considerable difficulty in calculating when miles were put on the cars, by whom, and for what purpose. A strong recommendation for any future program is to keep these basic records whenever a car is seen by the fleet manager or whenever a driver is moved into or out of a car.

Vehicles' Odometer Readings

As stated earlier, 154,802 miles were put on the CITIs during the Demonstration. Average miles per car per month varied considerably, as shown in Table 6 and Figure 10, from a low of 128 miles over 20 months to a high of 709 miles over 11 months. As the trend line indicates, the more months a car was in use, the lower its

average monthly use was. Total miles accumulated on each car also varied considerably—from a high of 8,975 to a low of 1,739. (Two cars were never driven, so the table and the figure represent 38 CITIs.)

Table 6. Miles Put on Each CITI

Car #	Total Miles	Months Available for Use	Average Miles per month
7	5,555	20	278
9	3,421	23	149
10	5,758	23	250
11	4,976	17	293
12	2,557	20	128
13	4,133	26	159
14	5,006	21	238
16	3,946	18	219
17	3,503	17	206
18	1,739	5	348
19	3,550	22	161
49	3,016	10	302
50	7,796	11	709
51	4,925	15	328
52	4,239	17	249
54	2,919	20	146
55	8,975	17	528
56	3,278	18	182
57	5,682	18	316
58	2,704	13	208
59	2,670	20	134
60	3,545	18	197
61	4,250	16	266
62	2,479	19	130
63	3,952	13	304
64	1,990	9	221
65	4,227	18	235
66	2,209	11	201
67	2,062	9	229
68	2,785	13	214
69	6,112	19	322
70	7,140	15	476
71	4,761	13	366
72	5,774	18	321
73	3,741	14	267
74	3,174	12	265
75	3,128	15	209
76	3,125	12	260
	154,802	Average 15.4	263

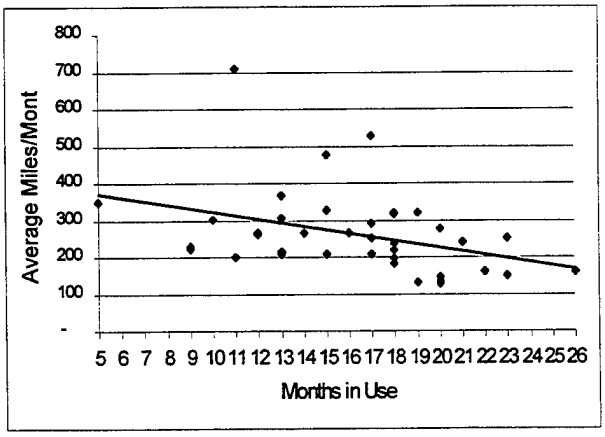

Figure 10. Use of CITIs, Miles per Month

Data Collection

Data collection is always a problem in a pilot project that includes the general public and many implementation partners. Odometer and kWh readings were missing for a few to several months for every vehicle.

Besides vehicle data, information was to be collected from participants at several points in the Demonstration: (1) opinion survey before driving and while in the program; and (2) a week of trip diaries before and during. The National Transit Access Center at the Institute of Urban and Regional Development, University of California-Berkeley, under contract to the City of

Emeryville, collected data from the Sybase participants. BART hired NSCA in mid-1996 to assist in monitoring the Demonstration, to assist in data collection, and to do the evaluation. NSCA hired an intern to assist part-time at BART headquarters and to collect BART employee data. Company coordinators helped collect data from the BofA and PG&E participants.

During the transition of receiving the final 28 CITIs, trying to get them roadworthy, and hiring the fleet manager, data collection was sporadic. GMW's goal was to get cars on the road with paying customers in them as quickly as possible. GMW wanted station cars to be a real business, so, understandably, data collection was not a primary concern. Sometimes the "before" survey and trip logs were given to drivers when they were put in cars (thus they were actually doing "during" surveys and trip logs), so it was necessary to try to get "after" data from them. Sometimes drivers entered the program without any data being collected.

Once in a car, getting participants to complete the "during" trip diaries and surveys was difficult. Several were contacted more than once by mail and follow-up phone calls. Most of the follow-up calls were to voice mailboxes and the participants did not return the call, even though detailed messages were left. Sometimes GMW would end a leasing contract, and put a new participant in a car without notifying NSCA in advance, so no "during" data for the outgoing participant and no "before" data for the incoming participant were collected.

The amount of data available and the fact that most participants had fairly regular trip-making patterns allowed the evaluation to be completed, but the data were not as robust as originally anticipated. The lesson learned here is that more resources need to be spent on data collection—it has to be someone's primary job, probably the person who recruits, trains, and otherwise interacts with participants. It appears that two types of people are needed to operate a station car program—one for fleet maintenance and another for "participant maintenance."

Lease Agreements

GMW drew up a seven-page lease agreement, plus a vehicle description form that included insurance information and a method of payment form. Because of its length and complexity, paperwork was included as a reason for not participating when people were asked why they declined to sign leases (see Section 7). In the last few months of the Demonstration, GMW designed a single-sheet, two-sided lease agreement that looked very much like those used by rental car companies. The difference between people's attitudes toward the two forms was not examined, but it is assumed that the shorter form was more appealing.

Lease payments were to be for three months at a time in order to reduce the paperwork burden for GMW. Payment could be by VISA, Mastercard, or personal check. GMW encountered problems in collecting payment from some people once they were driving cars, despite continued efforts on the part of GMW and BART. In at least one case, a car had to be taken from a driver who never paid for its use.

Insurance

The issue of how insurance for the drivers would be handled was seen as a potential major barrier to the Demonstration.[14] Earlier, BART had asked U.S. Electricar to search for a vendor that would insure the entire fleet for a million dollars per incident. U.S. Electricar found that this would mean an additional $100/month to cover BART employees using the cars for personal business.[15]

PIVCO's Product Liability Insurance was part of its Commercial General Liability coverage, with a $2,000,000 aggregate—a $1,000,000 limit on product defects and a $1,000,000 limit on personal injury. It also included a $25,000 limit on fire damage and $5,000 medical. Their premium was not disclosed.

GMW had similar Commercial General Liability coverage with a $2,000,000 aggregate and a $1,000,000 limit on personal injury. It also included a $50,000 limit on fire damage, $5,000 medical, and a $1,000 deductible on collision and comprehensive. GMW would have paid the deductible had there been any claims. GMW carried no Garage Liability, which is usually carried when automobiles are being maintained. GMW used three different carriers for comprehensive and collision in sequence during the Demonstration to keep the costs down and coverage up. The average premium was $35,000/yr. GMW's insurers required the drivers to have minimum liability insurance. There were no claims.

PG&E's self-insurance program covered its employee participants. BART's self-insurance covered BART employees who used station cars for BART purposes (e.g., the pool cars). Sybase and BofA covered their own employees. But, when the general public began applying for participation (including BART employees who used the cars for personal business), the insurance issue became highly problematic. GMW's solution was to provide collision and comprehensive for the cars, but drivers had to provide personal liability insurance.[16] Almost all users were able to provide liability insurance through their existing auto policies. However, some insurers increased their rates to include coverage of the station car; others treated the station car like a rental car, at no increase in rate.

Some participants did not own a car, so had no insurance, and found it difficult to obtain standalone personal liability insurance. At least three people who wanted to participate did not because of this problem. Another's agent said he needed the vehicle's VIN so he could "look it up." When he was told he would not find data on the prototype cars and that his client might be driving one of several cars at different

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[14] In all station car and car-sharing programs, insurance arises early in the planning process as a potential problem. Insurance companies do not know how to handle these innovative uses of prototype vehicles. A related issue is whether to permit participation by drivers aged 21-25.

[15] The Boston program charged $200/month, half of which was for insurance. [personal communication with David Dilts, Massachusetts Division of Energy Resources]

[16] One way to think of insurance is that collision and comprehensive "follow the car," while personal liability "follows the individual."

times, he refused to insure. GMW, for an extra $55 per month, allowed about six others with problems concerning liability insurance to participate.

SECTION 5. ENVIRONMENTAL AND ENERGY IMPACTS

Three types of impacts were analyzed for the Demonstration. First, the actual (i.e., measured) differences in use of the various travel modes by the participants (1) if the Demonstration had not occurred and (2) during the Demonstration. The second and third types of impacts were changes in air emissions and energy use due to participants' new travel habits.

Data for the impact analysis came from several sources:

1. The CITIs had on-board computers that recorded kWh during charging and were downloaded once a month or whenever a car was brought in for service.
2. Odometer readings were taken once a month.
3. Drivers completed entrance surveys that included information about their pre-program commuting patterns, as well as seven days of actual pre-program trip-making data in diary form.
4. Drivers completed seven days of diaries during the program when using the EV.
5. Drivers completed surveys either during the program or just after leaving.
6. For those EVs used by multiple drivers or as pool cars, mileage/use logs were kept on clipboards in the cars.
7. May 1996 emission factors were supplied by BAAQMD and PG&E.
8. Vehicle energy intensity were taken from the most recent publication of Oak Ridge National Laboratory's *Transportation Energy Databook: Edition 14* (May 1994).
9. BART supplied distances between all pairs of stations.
10. Other distances not supplied by the participants were measured on maps.

Calculation Methodology

The drivers' before and during trip diaries and their before and during surveys allowed the calculation of miles via each mode, energy consumption by energy type, and emissions by pollutant (1) for a scenario constructed as if each participant had not used a station car for the period of participation (denoted as "without") and (2) as actually occurred during station car use (denoted as "with"). Thus, modal splits, air emissions, and energy data were calculated two ways: *without* the Demonstration, as if the participants continued in their pre-Demonstration trip patterns, and *with* the Demonstration, i.e., what actually occurred.

Modal Splits

Figures 11 and 12 show *without* and *with* modal splits in percentages of total passenger miles traveled (pmt). Bike use would have been 705 miles without the Demonstration and decreassed 74% during the Demonstration. Walking would have

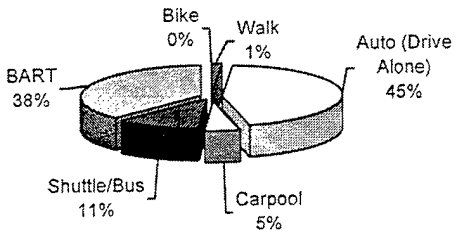


Figure 11. Modal Split Without Demonstration

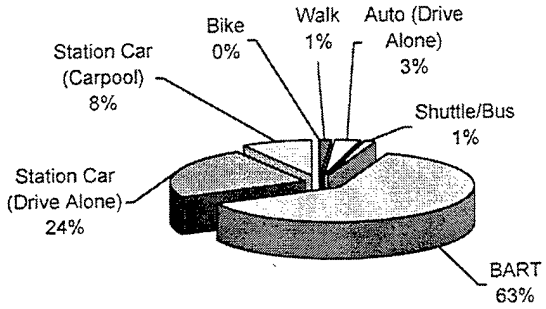


Figure 12. Modal Split With Demonstration

been 7,416 miles and increased 7.8%. All walking was in order to access BART or buses.

Conventional (internal combustion engine, or ICE) automobile pmt (including carpooling) decreased 94%. There would have been 16,572 ICE automobile trips, mainly on freeways, without the Demonstration. With the Demonstration, there were only 3,083 ICE automobile trips and most of these were short to access BART on the home end when a station car was used on the work end. Clearly, the impact of a large-scale deployment of station cars on freeway congestion would be significant.

Figure 13 shows pmt by mode *without* and *with*. BART pmt for the participants increased by 125,222 (56%) because of the Demonstration. In fares, this represented approximately $18,464 in increased revenue. Shuttle/bus pmt dropped 59%. Most of this was due to some Sybase employees no longer using the Emeryville shuttle between the work site and the MacArthur Station and BART employees no longer using a transit bus between the Colma Station and the BART work site.

Carpooling actually increased because carpooling was encouraged for participation in the Demonstration. There would have been 11 carpools without the Demonstration and there were 24 carpools with it.[17] The longest one during the Demonstration lasted 56 weeks by a couple driving between their home and BART; the shortest was 4.5 weeks. (Note: Station car vehicle miles traveled, or vmt, during the Demonstration was 154,802 and pmt was 179,474, for an average occupancy of 1.159.)

Environmental Impacts With and Without the Demonstration

The following analysis assumes that the use of the EVs resulted in no emissions of reactive organic gases (ROG) or oxides of nitrogen (NOx) in the Bay Area. While

[17] There actually was more carpooling in station cars than the data presents because rides were given to and from the Ashby Station by Sybase drivers on a random basis.

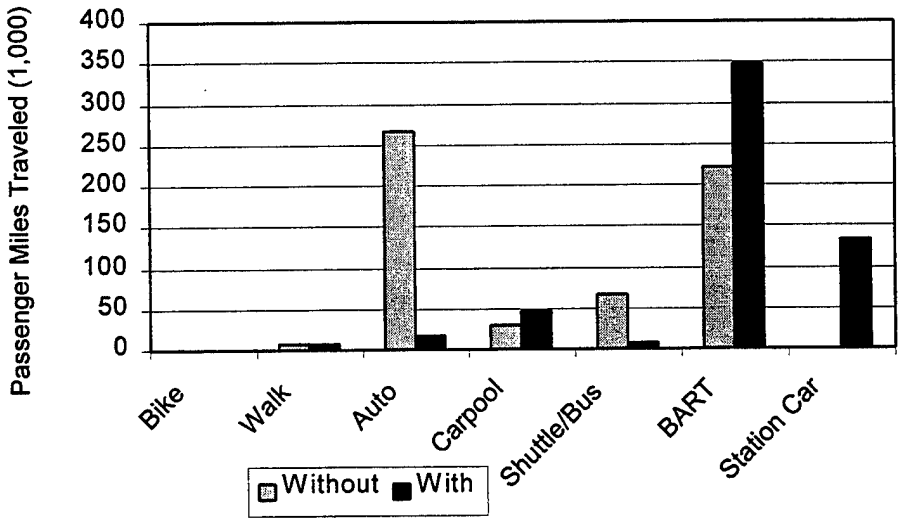


Figure 13. Modal Splits Without and With the Demonstration ("auto" and "station car" pmt exclude "carpool" pmt)

EVs obviously have no tailpipe emissions, the emissions associated with the generation of power for these EVs are so minimal as to be ignored, according to the Transportation Group at BAAQMD, except for carbon dioxide (CO_2). Also, no emissions were calculated for the changes in shuttle/bus usage because no buses were added or deleted as a result of the Demonstration. Thus, ROG, NO_X, and CO_2 emissions were calculated only for the use of ICE cars without and with the Demonstration. CO_2 emissions at the power plant were calculated due to station car charging. The emission factors are shown in Table 7. "Trip factor" in gm/trip accounts for emissions due to cold starts and warm soaks that take place at the beginning of and after an ICE car is driven. "Running emission factor" accounts for the emissions due to ICE car operation. The ROG and NO_X running emission factors are quite conservative and likely underestimate the running emissions significantly. Thus the reduction calculated here for the Demonstration should be viewed as a lower bound. Actual reductions were probably much greater by a factor of two or three. The CO_2 factors, however, should be considered quite accurate.

Table 7. Emissions Factors

Emission	ICE Car		Station Car
	Trip Factor (gm/trip)	Running Emissions Factor (gm/mi)	
ROG	4.98	0.55	0
NO_X	2.05	1.02	0
CO_2	19.8 (lb/gal)		0.243 (lb/kWh)

Table 8 presents the results of the emissions reductions, all of which are significantly large percentages.

Table 8. Reduction in Emissions "With" Compared to "Without"

Emission	Without (tons)	With (tons)	Reduction (tons)	Percent Reduction
ROG	0.262	0.017	0.245	93.5%
NO_x	0.353	0.007	0.346	98.0%
CO_2	128	12.8	115.6	90.0%

Energy Use

Data on electricity use (kWh) existed for 77,401 of the 154,802 miles the cars were driven because:

1. Kilowatt consumption could not be read from the two CITIs that had Horizon batteries and the four cars that had Hughes inductive chargers.
2. Problems with the chargers meant that the kWh reading were sometimes automatically reset to zero.
3. Some monthly readings were not taken.[18] However, the data available and used for this analysis are quite accurate.

The average kWh/mi for the analyzed miles was 0.34. The CITI with the poorest (largest) per mile energy use had a kWh/mi of 0.61. The best car recorded 0.22 kWh/mi. Figure 14 shows—for the cars with data—the wide variation in these data. "First Cars" refers to the first 12 CITIs delivered. Ten had sufficient data to allow a reliable calculation, yielding an average energy intensity of 0.29 kWh/mi. Of the 28 "Second Cars," 19 had sufficient data, which yielded an average of 0.36 kWh/mi. The variations are no doubt a function how optimized each car was and probably different driving patterns. The energy intensity of 0.34 kWh/mi was high for EVs of this size. [19]

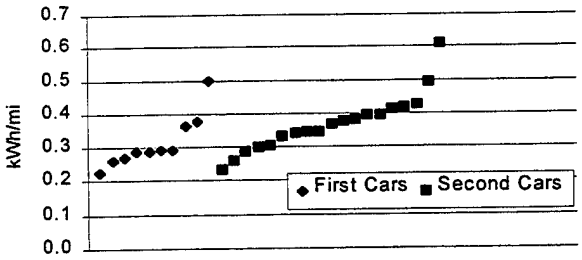


Figure 14. Energy Intensities of 29 CITIs

Part of the reason the "First Cars" were more energy efficient is because they had smaller battery packs and were lighter. Another reason for the difference between the two groups could be ascribed to the differences in the controller and charger.

[18] The cars were not always at the stations so readings could not be taken and, early on in the Demonstration, not many kWh readings were taken.

[19] GMW reported between 0.3 and 0.4 kWh/mi on the EV1s in urban driving. The EV1 weighs one-third more than the CITI.

During the Demonstration, the CITIs consumed 52,720 kWh (or 4,639 gallons equivalent of gasoline, which accounts for losses in electricity generation and transmission and can be thought of as the energy equivalent of gallons of gasoline into the power plant)—about the same amount that five households consume in a year. The reduction in gasoline use by driving alone or riding in carpools using conventional cars versus using BART and station cars was 12,322 gallons, for a net reduction of 7,683 gallons equivalent. No energy changes were calculated for BART or buses because the number of trains and buses running remained the same.

Impact Scenarios

Because the cars had so much down time, because most participants were not "ideal" (see Section 6), and because the Demonstration was small, the three following scenarios were created based on the preceding impact calculations:

1. **With Ideal Cars**. In this scenario, the Demonstration is exactly the same (i.e., same participants for 2.5 years), but with 40 cars that had no downtime other than routine maintenance and repairs. To accommodate the need to bring cars into the shop periodically, one car was a spare for the first 9 months in this scenario; two cars were spares for the remainder of the scenario. Thus, for this scenario, the impacts were factored up by 33.4% to simulate reduced downtime.
2. **With Ideal Participants**. Here, "ideal" means each participant drove alone, round-trip, to work before the demonstration and used BART and a station car (at one end of the commute) during the Demonstration. Five ideal home- and work-end participants were chosen from the Demonstration data, such that they had varying lengths of time in the Demonstration and varying lengths of commute. All drove alone to work before the Demonstration. During the Demonstration, three walked at one end of their BART/station car commutes and two used ICE cars at the home end of their BART/station car commutes. The Demonstration data on these five were factored up to represent the same station car vmt as in the "With Ideal Cars" scenario. In other words, station car vmt was kept at the level of the previous scenario to show the added effects of having ideal participants.
3. **10,000 Station Cars**. This scenario was constructed to show the impact of large numbers of station cars in the Bay Area. The number 10,000 was chosen because it is easy to factor the results up or down. To put 10,000 station cars in perspective, BART has approximately 40,000 parking spaces at its stations. Ten thousand commuters represents 5% to 10% of the potential work-end market of station cars.[20] The scenario models *one year* of operation of a full-scale program each day for 50 weeks. The five ideal participants' vmt were factored to 50 weeks, and then factored up to 20,000 participants (2/day/car). This "ideal" scenario gives an indication of what could happen in the future.

[20] Spiekerman and Weinstein. "Evaluation of the Potential Commuter Market for Station Car Usage at the Bay Area Rapid Transit District." 77th Annual Meeting, Transportation Research Board, Washington, January 11-15, 1998.

Table 9 gives selected results of the Demonstration for the first two scenarios. Figure 15 gives vmt and pmt changes between "Actual Results" and the first two scenarios. Figure 16 illustrates the reductions for ROG, NO_X, and CO_2. Though the percentage change does not differ from step to step in making the actual demonstration more ideal, as the column labeled "Change" in Table 9 clearly shows, each step results in increasing the magnitude of the benefits. The switch to ideal cars resulted in some improvement and the switch to ideal participants resulted in a significant improvement due to a significant modal shift from ICE cars to BART. This might also result in positive freeway congestion impacts.

Table 9. Actual and Scenario Results

Scenario	Parameter	Without[a]	With[a]	Change	Percent Change
Actual Results					
	ICE (vmt)	281,094	14,007	-267,086	-95.0%
	Station Car (vmt)	0	154,802	+154,802	b
	BART (pmt)	222,146	347,368	+125,222	+56.4%
	ICE Gasoline (gal)	12,969	646	-12,322	-95.0%
	ICE + Station Car (gal. equivalent)	12,969	5,286	-7,683	-59.2%
	ROG (tons)	0.262	0.017	-0.245	-93.5%
	NO_X (tons)	0.353	0.007	-0.346	-98.0%
	CO_2 (tons)	128	12.8	-116	-90.0%
With Ideal Cars					
	ICE (vmt)	375,123	18,693	-356,430	-95.0%
	Station Car (vmt)	0	206,585	+206,585	b
	BART (pmt)	296,457	463,568	+167,111	+56.4%
	ICE Gasoline (gal)	17,307	862	-16,444	-95.0%
	ICE + Station Car (gal. equivalent)	17,307	7,054	-10,253	-59.2%
	ROG (tons)	0.349	0.034	-0.315	-90.3%
	NO_X (tons)	0.472	0.030	-0.441	-93.6%
	CO_2 (tons)	171	17.1	-154	-90.0%
Plus Ideal Participants					
	ICE (vmt)	1,305,074	66,914	-1,238,160	-94.9%
	Station Car (vmt)	0	206,585	+206,585	b
	BART (pmt)	0	959,945	+959,945	b
	ICE Gasoline (gal)	60,211	3,087	-57,124	-94.9%
	ICE + Station Car (gal. equivalent)	60,211	9,278	-50,932	-84.6%
	ROG (tons)	1.001	0.185	-0.816	-81.5%
	NOx (tons)	1.553	0.135	-1.418	-91.3%
	CO_2 (tons)	596	39.1	-557	-93.4%

[a] "Without" means what would have happened without the Demonstration or scenario and "with" means what occurred with the Demonstration or was calculated for the scenario.
[b] Percentage cannot be calculated because the denominator is zero.

The results of the calculations for the "10,000 Station Cars" scenario are shown in Table 10. In this scenario, all participants would be commuting alone in ICE cars without the program and, with the program, driving station cars and riding BART (some work-end station car users would be accessing BART at the home end with their ICE cars). This scenario was constructed to maximize the energy and environmental benefits. The *without* ICE vmt and gasoline consumption would be 290 million miles and 13 million gallons. If the program were in place, that vmt would be replaced by 10 million miles via ICE, 43 million via station cars, and 218 million

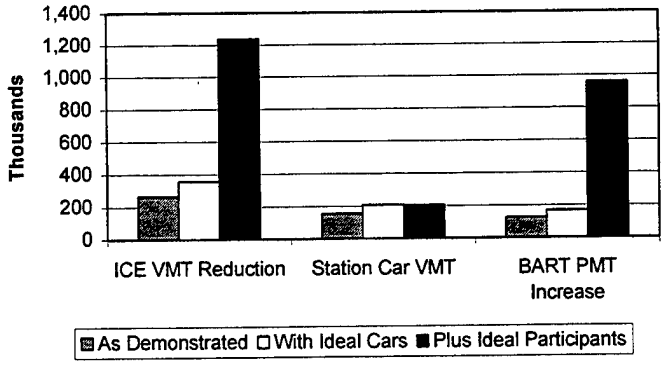


Figure 15. Changes in vmt and pmt for Each Scenario

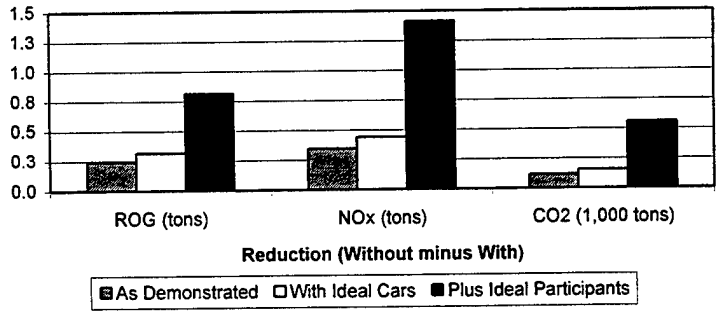


Figure 16. Reductions in Emissions for Each Scenario

pmt on BART. In fares, this translates to a $32.8 million annual revenue stream.[21] There would be a little additional walking. As Table 10 shows, the change in gallons equivalent is large because station cars become electrically and mechanically optimized and thus very energy efficient. The cost of electricity for operating the cars becomes about a penny a mile. The emission reductions are much larger, but consistent with the percentages in the other scenarios and the Demonstration itself.

Table 10. The "10,000 Station Cars" Scenario Annual Impact

Parameter	Without	With	Change	Percent Change
ICE (vmt millions)	290	10	-280	-96.5%
Station Car (vmt millions)	0	43	+43	a
BART (pmt millions)	0	218	+218	a
ICE Gasoline (gal millions)	13.3	0.5	-13.0	-96.6%
ICE + Station Car (gal. equivalent millions)	13.3	1.0	-12.3	-92.4%
ROG (tons)	230	28	-202	-87.8%
NO_X (tons)	348	20	-328	-94.2%
CO_2 (tons)	132,347	5,342	-127,005	-96.0%

[a] Percentage cannot be calculated because the denominator is zero.

[21] Using the average 1997 fare of 15¢/mi.

In 1998, BART was producing about 900 million passenger miles per year. Average trip length was 12.75 miles. Average trip length on BART for 20,000 station car users would be 21.8 miles, assuming that BART would be used 50 weeks a year, five days a week, two trips per day. This trip length makes sense because these participants are not coming from urban stations, but from suburban stations. Thus, 10,000 station car users could have a large revenue impact on BART.

Figure 17 shows the dramatic modal shift for this scenario. In terms of trips, 10 million long trips (averaging 29 miles, mainly on freeways) via ICE cars each year are replaced with 4 million short station access/egress trips via ICE cars (averaging 2.5 miles, mainly on local streets), 10 million short station car trips (averaging 4.2 miles, mainly on local streets), and 10 million long BART trips (averaging 21.8 miles). This scenario removes 40,000 ICE commute trips a day from Bay Area freeways, while the change in local street driving is probably minimal.

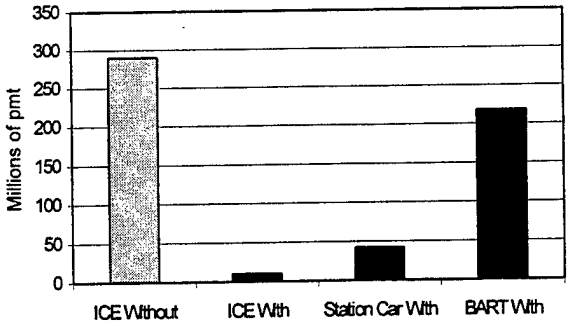


Figure 17. Modal Shift from ICE Car for the "10,000 Station Cars" Scenario

The station cars would free up space in BART parking facilities. That space could be used to attract additional forward commuters, transit-oriented development (TOD), or a combination of both. Reverse-commute station car users would be recruited mostly from non-BART riders.

In a conventional parking lot, 70 acres would be needed to park 10,000 cars. Assuming that the 10,000 station cars are used by 10,000 existing forward-commute patrons and 10,000 reverse commuters who were not previously BART riders, possibly only 50% of the 10,000 station cars would be at a station at any one time. The cars would be parked in queues, thus requiring only 10 acres for parking and returning 60 acres to TOD. Stated differently, BART may not need to make money on station cars because it would have revenues from 10,000 new fares each weekday and from leasing 60 acres to TOD. The station car service provider could then become a commercial venture in the TOD.

While the assumptions behind the "10,000 station cars" scenario are idealistic, fielding such a program in a few years is certainly feasible because the technology will be ready due to three advances:

1. The improvement in EV technology since the Demonstration began is significant, with additional improvements expected in the next few years.

2. The electronics to allow such a demonstration exist now (i.e., the reservation system, the vehicle access system, the vehicle tracking and diagnostic systems,

the fleet management systems, and the customer billing system)—they just have to be packaged for the station car application.

3. Queues of EVs are not difficult to conceptualize, construct, and operate.[22]

The "10,000 station cars" scenario results show that the station car concept could have the potential of improving the transportation related problems in the Bay Area during the first decade of the next century, especially if it is extended to the other Bay Area rail systems, ferries, and some express bus routes.

[22] To minimize the amount of land used for parking station cars, the cars would be parked in queues. Users would leave a car at the end of the queue and later take one from the front. The cars would move through the queues automatically while their batteries are being charged.

SECTION 6. NON-QUANTIFIABLE IMPACTS

The Demonstration produced many non-quantifiable effects, many of which may be more important than the quantifiable ones. During the Demonstration, the station cars dripped no gasoline, crankcase oil, transmission fluid, or coolant onto streets and parking places, which would eventually drain to the San Francisco Bay. While the cars were noisier inside because of the reduction gear noise, they were extremely quiet outside, reducing urban background noise. From a complete stop to when they started to accelerate, people encountering one for the first time were consistently amazed that the cars could move without noise.

Socially and educationally, the station cars were a hit. Thumbs up and big smiles from pedestrians and others in adjacent cars were common. Coming back to a CITI parked in a grocery store lot or on the street, a participant would often encounter a parent explaining to a child what it was or a few teenagers looking it over and ready to ask questions. How fast will it go? How far will it go? How much does it cost? Is the electricity expensive? Where can I get one? When they were driven in parades or brought to events, people were given rides. Friends, neighbors, and relatives of the participants were given rides. Visitors to the Demonstration, including the U.S. Secretary of Transportation, were given rides. A number of participants were self-appointed ambassadors, and enjoyed such things as making presentations at local schools to explain the CITIs and give children a close look. These encounters no doubt occurred thousands of times. Many more thousands saw them at the San Francisco Auto Show in 1995[23] and 1996, and at the Alameda EV Expo in 1997. Everybody who encountered them asked questions and learned about EVs.

Because of this broad exposure, extensive national/international press coverage, and their visibility on a daily basis in the Bay Area, possibly millions of people learned that small EVs are real, are here today, and are providing pollution-free transportation. This awareness will encourage people to explore owning an EV when the option is presented to them. It will no doubt help the EV industry sell/lease EVs. It will help the local economy if, as planned, the EV industry establishes manufacturing in the Bay Area.

The Demonstration has brought BART, the sponsors, and the members of NSCA far up the station-car learning curve. They will now be able to design and test additional and more complex aspects of the concept.

The Demonstration has built station car momentum, both inside BART and in funding agencies. The Demonstration did not end on March 31, 1998, as expected. GMW and the City of Berkeley are continuing the multi-user demonstration they began just before the official end of the Demonstration. GMW continues to deploy some of the CITIs and other EVs it used during the Demonstration. Rental car companies and carmaker R&D offices have approached BART to do additional, more complex, demonstrations. Two manufacturers have donated cars to be used in these

[23] The finish on the corner of the car closest to the crowds shows a little wear due to people touching it.

additional demonstrations. BART has been seeking funds to do market research and, in June 1998, a state agency offered support for the work.

SECTION 7. PARTICIPANTS

Descriptions of Demonstration Participant Types

It is not unusual in demonstration programs and field tests for project managers to make changes in the design, either due to unexpected changes in circumstances external to the program or in order to test concepts not originally included in the design. Both situations occurred in the Demonstration. Opening the Demonstration to the general public created an opportunity to test some additional programmatic questions about participants:

- What was the public willing to pay per month for a lease at either the home end or work end of a commute?
- What was the most effective way to recruit subscribers from the general public?
- What were the most effective arguments for convincing someone to become a subscriber?
- After making a request for a contract, what were the reasons for deciding not to become a participant?

In answering these questions, users of electric station cars were grouped into nine categories:

1. **Home-end users** (Figure 18 shows a couple who carpooled to BART). One type of "ideal" station car user is the person who replaced an all-ICE vehicle commute with an all-electric commute (station car from home to BART, BART to work and back, station car to home), and then used the EV for errands at night and weekends. Within the total of 94 participants, seven fit this description.

Figure 18. Ann Patterson and Bradley Allen were the First Participants from the General Public (home-end carpool couple, participating for environmental reasons and because their ICE was barely driveable)

2. **Work-end users.** Another ideal user is a person who drove all the way to work only because BART (or other public transportation) could not get all the way to

the work site. As a participant, the user could commute on BART and use a station car from the destination station to the work site and back. Eighteen people participated for this reason.

3. **Transition users.** Two people did not have cars at the time they entered the program, but bought cars upon leaving the program. Diary data were collected during the program and after they left and were driving ICE cars.

4. **Multiple drivers.** Two tests were conducted during January-March 1998. One tested round-the-clock sharing of three cars among 8 hospital workers as they rotated shifts and drove between the Lake Merritt Station and Alameda Hospital. In the other case, three City of Berkeley employees shared cars from the Ashby Station to work, used them as pool cars during the day, and the same employees took them back to BART at the end of the day. The cars were not assigned to specific drivers, but drivers were limited to those recruited. The same cars were taken home at night by home-end users

5. **Dedicated pool cars.** Two CITIs were used by BART staff as pool cars during the day throughout the Demonstration. Data were collected via clipboards.

6. **Home-end, already BART riders.** Twenty-three people were in this category.

7. **Work-end, already BART riders.** Nineteen people met this profile, mostly Sybase and BART employees.

8. **Semi-ideal, new BART riders, home-end.** The three people in this group were "semi-ideal" because they replaced a commute that used another form of public transportation, such as an express bus.

9. **"Not even close . . .."** Seven people were in this group. One driver did not have a car either before or after the program; rather, he was replacing shuttle/bus or walking trips to get to BART. One person entered the program intending to be an "ideal" user, but when she began working at home, she continued to drive her CITI and used BART only occasionally.

Recruitment and Marketing

Among the challenges facing station car and car-sharing programs that use EVs rather than ICE cars are recruiting participants who meet the program's "profile," determining the appropriate fee/lease structure, and meeting drivers' needs within the limitations of the program's infrastructure.

Recruitment of participants from BART, PG&E, Sybase, and BofA was coordinated within each organization by someone assigned to the task. These people interfaced with Demonstration management. Because these internal recruitment methods were relatively straightforward and no data were collected about them, they are not addressed further in this section. Rather, this section focuses on recruitment and marketing to the general public.

Four methods of marketing the station cars were tested to determine which one (or which combination) was most successful in recruiting participants from the general public.

1. Placing prominent ads in neighborhood newspapers.
2. Displaying the vehicles at highly trafficked places, answering questions, and taking mailing information for those seriously interested so lease contracts and data collection instruments could be mailed.
3. Placing flyers at the BART stations with station car charging facilities.
4. One-on-one contacts were made via an e-mail link on the NSCA web site, a phone number on the back of each vehicle, word-of-mouth, and several television news items.

In the beginning of the marketing effort, it was assumed that simply running an ad in local newspapers (serving Berkeley, Oakland, Piedmont, and Alameda) would result in phones ringing off the hook, compiling a list, and selecting the top candidates for participation, leaving a waiting list to tap as people dropped out and cars became available. Screening sheets were developed to ensure that "ideal" candidates could be selected who would use the Ashby Station. The ad (shown in Figure 19) ran for two weeks in late March 1997 in the newspapers, resulting in dozens of responses and two contract packages for $150/month sent out. Although both contracts were signed, they turned out not to be CITI users, as they leased other EVs from GMW for $100/month.

The first of several "display tests" was in front of an up-scale grocery store near the Ashby Station on a Saturday morning, offering the CITIs at a $200/month lease rate. Although the CITI attracted considerable attention and myriad questions were answered, only one person wanted a contract and he did not follow through. The next attempt to reach potential subscribers one-on-one was at Berkeley's Earth Day celebration in April 1997, using a $200/month lease rate. Fifteen CITIs and a few other EVs were in the parade and on display at the town square for touching and driving. Despite many in-depth conversations and handing out hundreds of flyers, of the six contracts requested and sent out, none was completed. In the third test, several hours (including the evening rush period) were spent in front of the Ashby Station with a red CITI on display, positioned so that people going to their cars would walk right past it. No $200/month contracts resulted, but contact was made with the head of a group that is building a co-housing facility in downtown Oakland and wants a couple of EVs for car-sharing (probably in 1999).

In late April, flyers were placed at the Ashby Station. Fourteen contracts were sent to people who called for more information. Four contracts were signed, but one had to drop out because he could not provide personal liability insurance. Two of the remaining three were leased at $200/month; one was $155/month, including $55 for liability insurance. Also at this time, a $100/month lease rate was tested because some people were saying the $200 rate was too high. In early May, similar flyers were placed at the Walnut Creek Station, with the lease raised to $200/month. Of seven contracts mailed, none was completed. In November, flyers were again placed

A UNIQUE OPPORTUNITY
TO BE AN ELECTRIC VEHICLE DRIVER

- If you ride BART from the Ashby Station (or would if you could get back and forth from home)

AND

- Live at least half a mile and less than five miles from the station

AND

- Drive your car to the station and leave it during the day

AND

- Want to have the use of a two-passenger ELECTRIC VEHICLE when you are not working

AND

- You want to help collect data to demonstrate the value of ELECTRIC VEHICLES in improving our environment

AND

- You are over 25 and have auto liability insurance

AND

- You are willing to pay $150 a month to participate

CALL 510-839-6054
FOR MORE INFORMATION ON HOW YOU COULD PARTICIPATE IN THIS EXCITING PROGRAM!

Figure 19. Ad Placed in Neighborhood Newspapers

at Walnut Creek and two of the six contracts prepared were signed—one for $200 and one for $150.

Throughout the Summer and Fall of 1997, recruitment was by word-of-mouth, calls to the phone number on the back of each car, contacts via the Internet, and local parades. Of the 42 contracts prepared, 14 were completed. Rates ranged from $95/month for BART employees to $200/month for the general public.

In conclusion, the most effective (and efficient) way to recruit from the general public, particularly in the beginning, is to find large corporations that are willing to find employees who want to participate. The advantage is that these people have a sense of belonging to a group, with support provided by their employer (and perhaps some incentives) perhaps through its internal e-mail system. In addition, if data collection is important to the project, the corporation's coordinator can be extremely helpful in ensuring its collection.

Participant Demographics

Between November 1995 and March 1998, 94 people were in the Demonstration, including two-person carpools and multiple-user tests. In addition, some cars were used as pool cars or, when vehicles were available, on a short-term basis by people not in the program. If these pool drivers are added to the many spouses and housemates who also drove the cars, well over 200 people experienced driving the CITIs.

Perhaps even more interesting is that, although subscribers were asked to participate for three months, they were given the option of continuing. The average length of membership among the general public during the 12 months when they could join was 6.4 months. The average time employee participants were in the program was 12.7 for BofA, 7.6 for BART, and 10.1 for PG&E over a 19.5-month period; the average for Sybase was 6.0 months over a 9-month period. The people in the program longest were three BofA employees who had CITIs for 19.5 months and were "ideal" participants. Totals are shown in Table 11 by organizational affiliation and months in the cars. Because carpool makeup sometimes changed, each person, whether rider or driver, experienced a specific number of car-months. (These are not the same "car-months" used in Section 4 to describe the availability of the CITIs; rather, they describe the number of months each participant was in the Demonstration and using a car.)

Table 11. Affiliation of Participants and Time in Cars

Organization	Participants[a]	Car-Months	Average Car-Months	Range of Car-Months
Sybase	22	131.0	6.0	0.5 to 9 (mode 6)
Bank of America	9	114.0	12.7	3 to 19.5 (mode 19.5)
BART/BART Contractor	23	175.5	7.6	2 to 15 (mode 7)
PG&E	4	40.5	10.1	7 to 13.5 (no mode)
General Public	22	140.0	6.4	1 to 17 (mode 4)
Total[a]	**80**	**601.0**	**8.5**	

[a]Excluded from this table are the 14 non-program drivers and multiple users in the Alameda Hospital and City of Berkeley experiments.

Months in the program for all participants is shown in Figure 20. Figure 21 illustrates how many people were in the Demonstration by organization each month. This figure also illustrates the considerable movement of people in and out of the Demonstration.

Although more participants were male, the difference was not significant (53, male; 41, female). Neither does the breakdown by organizational affiliation, in Table 12, shed light on any significance to participation by gender. However, the reasons for participating were different depending on gender. Men tended to be more interested because of the EV technology; women were more environmentally oriented.

Information in Table 13 illustrates the variances in both trip type (home-end-vs. work-end) and preferred station location. Trip-type was nearly equal, primarily due to the Sybase and BART employee work-end uses.

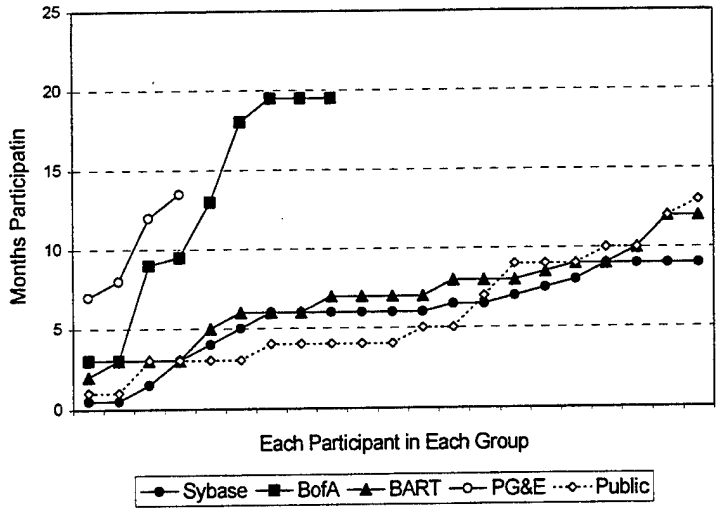


Figure 20. Months Each Person was in the Demonstration

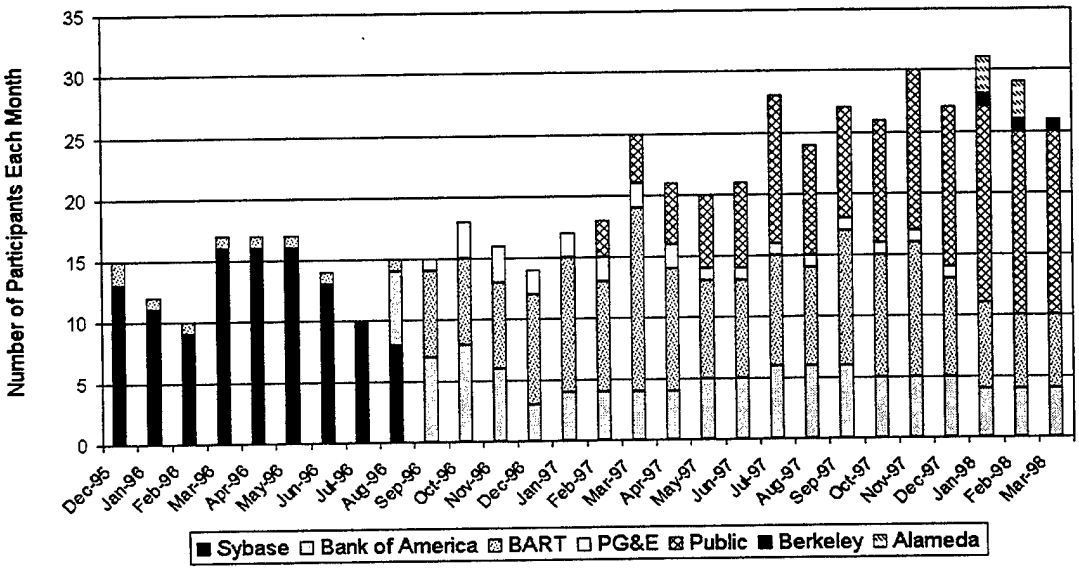


Figure 21. Participants Using CITIs Each Month and Their Affiliations

Table 12. Gender of Participants

Organizational Affiliation	Male	Female
Sybase	14	8
BART	15	9
PG&E	1	3
BofA	3	5
Alameda Hospital	3	5
General Public	15	10
Total	**53**	**41**

Table 13. Stations and Trip Purposes

Participant Group	Work-end	Home-end
Sybase	Ashby, 22	None
BofA	None	Colma, 1 Ashby, 6 Walnut Creek, 2
PG&E	None	Colma, 3 Walnut Creek, 1
BART	Colma, 15 Hayward, 1	Walnut Creek, 7 Lake Merritt, 1 Ashby, 1
Public	Colma, 1 Lake Merritt, 1	Ashby, 12 Colma, 3 Walnut Creek, 5
Total	**Ashby, 22** **Colma, 16** **Lake Merritt, 1** **Hayward, 1**	**Ashby, 19** **Colma, 7** **Lake Merritt, 1** **Walnut Creek, 15**

Participants' Reasons for Participating in the Demonstration

Reasons for wanting to participate were collected before driving, as were opinions while in the Demonstration. Reasons (*verbatim*) before are grouped into four categories—environmental, interest in electric vehicles, better commute, and avoid purchasing a car.

Environmental Reasons

- *I support research into all alternative transportation and/or energy sources to alleviate our dependence on our finite fossil fuels, which pollute the atmosphere.*
- *Better for air.*
- *I support the emission-free aspect of the commute.*
- *I am interested in reducing air pollution.*
- *Even though I do drive to work sometimes, I would prefer not to pollute.*
- *As an alternative to fossil-fuel burners, I believe electrics are modernistic and far more efficient for air quality.*
- *This car will be convenient and economical, better for our environment.*
- *Environmental; "heard" great things.*
- *I want to help the environment—I think it is a sin how much pollution I make just to get around.*
- *Environmental reasons as well as innovative alternative.*
- *Environmental impact.*

Interest in Electric Vehicles

- *I want to learn more about electric cars—it sounds really interesting. I think it makes sense to use them more and want to be involved in helping that happen. It's also a way to learn more about something new—expand my horizons.*
- *Believe in utility of small electric cars.*
- *I am interested in electric car technology.*
- *As we go into the high tech arena, I got very interested on how electric driven vehicles operate and decided to join this project.*
- *I'm interested in the electric car technology and willing to drive to see for myself. The cost is reasonable.*
- *I am an electrical engineer and I am fascinated by the technology.*
- *Interested in electric car feasibility.*
- *It is a fun idea to test the electric cars.*
- *Electric cars seem to be the car of the future and I wanted to try it out. Being at the forefront of this new technology is very exciting.*
- *Try out new types of transit.*
- *It is economical, environmentally safe, state of the art, fun.*
- *I make several cold starts per day—perfect application; advancement of EV application and technology; environmental concerns.*
- *Ecology, economy, high "coolness" factor.*
- *I am a strong supporter of environmentally friendly alternative power technologies in general and electric cars in particular. I am excited to help prove the feasibility of this type of vehicle.*
- *I want to do whatever I can to promote EVs and get people thinking about it.*
- *I am interested in purchasing an electric car.*
- *I have long been interested in electric cars and wish to test one.*
- *Impact on providing data for future use of electric vehicles.*

Better Commute

- *Allows me to use BART without need for bus.*
- *Bicycle not convenient in office clothes (suit); bicycle not convenient with briefcase.*
- *An electric car with guaranteed parking close to the station would allow me to commute to work without pollution.*
- *Flexibility to/from Colma and BART Millbrae office (often spend 1 hour/day waiting for bus plus 1.5 hour commute, each way).*
- *Bus schedule does not work well with the BART schedules. Waiting for bus plus*

transit is 40 minutes each way.

- *Tired of driving, I would prefer to take BART.*
- *It should help make my commute convenient, by reducing travel time.*
- *To cut travel time between BART station in Colma and Millbrae office.*
- *Do not own a car. Trip to and from Colma BART station is slow on SAMTrans buses and standing room only during school year.*
- *Avoid riding the stop-and-go city bus from Colma to Millbrae office.*
- *I'm tired of driving on 880. There's too much stress, construction, and people driving on the freeway. I like having someone else do the driving.*
- *Sometimes my drive takes 2 hours one way; also would like to see fewer cars on freeway—do my part.*
- *I want to use BART but only have one car and can't get from BART to work.*
- *To participate in using public transportation; eliminate bus rides (too infrequent buses).*
- *Muni bus and underground is too unreliable, slow, and annoying. I am frequently late to work because of Muni and the station car would enable me to totally avoid the city buses.*
- *Parking.*

Avoid Purchasing a Car

- *Have been considering a second car—especially for when I come home late at night, do small errands, etc.*
- *First car with no need for gas.*
- *An electric car will save wear and tear on my vehicle and, also, I only travel short distances with my only child.*
- *I currently have a 20-year old car that I use almost exclusively for driving to BART and back, with a few local trips per week. I want to replace it with an ecologically friendlier vehicle.*
- *I'm interested in supporting electric car technology and I'm trying to put off buying a gas-powered car, which I will probably have to do soon.*
- *We are a two-car family, but neither of us uses our cars as a primary means to get to work. It seems unnecessary to own two gas guzzling vehicles.*

It is clear from their reasons for participating that people who displayed interest in the Demonstration were true innovators,[24] which are precisely the kind of people desired for a project such as this. That they were innovators is borne out by the large number who participated primarily because of the EV technology. Another way to describe innovators in a population is in terms of psychographic characteristics that describe consumer values and value systems; this is illustrated by the large number who participated because they believed the program benefitted the environment. The implications of these characteristics is important to keep in mind when marketing and recruiting for the program—a two-pronged effort is required that appeals to both the technical and the environmental aspects of participating. Furthermore, as the program grows, the innovators act as the leaders who convince others to follow until the concept is seen as a mainstream alternative.

Figure 22 displays the relative importance of benefits and limitations of electric vehicles and the Demonstration given by drivers *while in the program.* It is not surprising that the environmental benefits are still highly rated, but "no vehicle maintenance" was third—higher than "more convenient mass transit" (a major reason given before entering the program), which was rated slightly higher than "not stopping at gas stations."

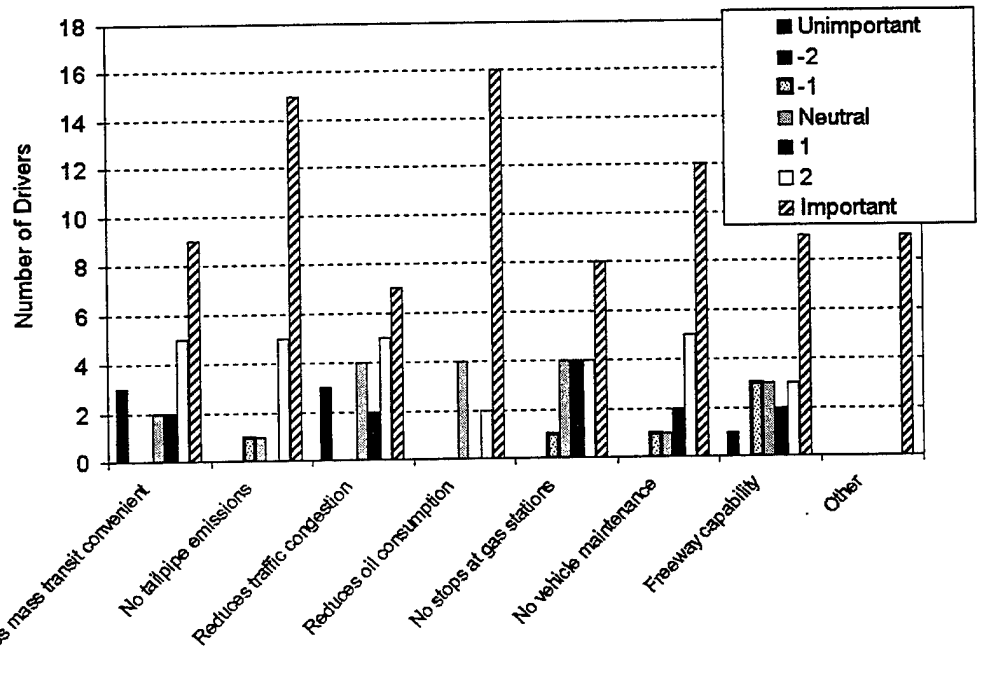


Figure 22. Reasons for Wanting to Continue Driving an Electric Station Car

[24] "Innovator" is the term used by sociologists to describe the 2.5% of a population that is first to try a new technology or adopt a new idea. They are followed by "early adopters" (13.5%), "early majority" (34%), "late majority" (34%), and "laggards" (13.5%); a small group (2.5%) will never adopt the innovation.

Reasons for Not Participating

People who were sent contracts, but did not sign and return them, were contacted by phone and mail to learn their reasons, including sensitivity to the lease rate. Of the 62 such contracts, responses were received from 28, or 44%.[25] People were not limited to the number of reasons they had for declining, but were asked to rank their reasons as to importance. Results are summarized in Table 14.

In addition, comments by people who called for more information but did not request contracts emphasize these reasons, with the additions of: "Why should we pay to participate? Shouldn't we be paid? Why doesn't BART give us free ridership to participate?" Others simply thought the cost was too high, didn't want to give up commuting, excused themselves as not being appropriate participants, and many other diverse reasons.

Table 14. Reasons for Declining to Sign Contracts

Rank (1 = highest) ⇒	1	2	3	4
Cost too much per month (10)	6	2	1	1
Want to buy, not lease, an electric vehicle (4)	2	1		1
"Technical" characteristics of the CITI (e.g., range, charging, speed, reliability) (6)	1	4		1
"Use" characteristics of the CITI (e.g., passenger capacity, safety) (8)	2	1	5	
Too much or confusing paperwork; contract language (2)	1	1		
Could not drive on the freeway (10)	4	2	4	
BART station would be inconvenient (2)		2		
Spouse/partner did not want to participate (1)	1			
Decided to buy a car (3)	1		1	1
Circumstances changed (moved, new job) (8)	7			1
Problem providing personal liability insurance (4)	3	1		
Lost/misplaced the paperwork (0)				
No reason given; moved; disconnected phone (5)	5			

Continued Interest in Station Cars

While in the program, participants were queried about their interest in continuing to use station cars at the home-end, work-end, and both, on a scale of –3 ("very unlikely") to 3 ("very likely"). Of those for whom data were available, nearly everyone rated the home-end as "3" (average = 2.95), while work-end and both-ends were rated negatively (-0.09 for work-end and –1.16 for both ends). However, opinions were correlated to how respondents used their station cars. *All* of the home-end users would continue to use station cars at the home end, but only 36% would want to switch to using them at the work end (14% had no opinion and half were very unlikely). Ninety percent of the work-end users would switch their use of station cars to the home end and 60% would continue using them at the work end. Table 15 illustrates these differences. The primary reasons for continuing were convenience, a good commute, good for the environment, and "love the car."

[25] A simple one-page mail-in questionnaire was sent to 44 people who had not been reached by phone; 36% responded; these 16 responses were added to the 12 contacted by phone.

Table 15. Interest in Continuing to Use a Station Car

Interest in Continuing	Home-end User in Demonstration		Work-end User in Demonstration	
	Continue Home-end	Switch to Work-end	Continue Work-end	Switch to Home-end
Likely (3)	100%	36%	60%	90%
Unlikely (-3)	0%	50%	30%	0%

Opinions about the Vehicles by Drivers

While driving the CITIs, participants were asked to rate the cars in terms of 16 features on a 7-point scale of –3 ("very poor") to +3 ("excellent"). The averages in Table 16 for each feature do not represent how much opinions varied among the participants. For example, while range was a problem for many people, appearance and hill climbing were of no concern to many others. In response to another question, ***participants rated their overall experience with the station cars as quite high (average of 2.33 on a scale of –3 to 3).***

The average ratings range from a high of 1.68 for acceleration to –0.21 for hill climbing. The poorly-rated physical features of the CITI that were clearly related to the prototypical nature of the vehicle were offset by the pleasure in the car's appearance. Users frequently named their cars and did not like it when they had to switch to a different one. This issue needs to be addressed when designing and implementing future multiple-user programs, and may be related to how the program is promoted—lease vs. own—and niche market(s) being served.

Table 16. Average Ratings by Participants about CITI Features

Feature	Average rating	Feature	Average rating
Acceleration	1.68	Passenger comfort	0.95
Vehicle appearance	1.36	Maximum speed	0.86
Maneuverability and handling	1.32	Cargo space	0.73
Passenger space	1.24	Range	0.24
Overall performance	1.18	Ride quality	0.23
Braking (deceleration)	1.16	Interior noise	0.08
Driver comfort	1.13	Vibration	-0.08
Reliability/availability	1.09	Hill climbing	-0.21

SECTION 8. ECONOMIC ANALYSIS

A detailed economic evaluation of the Demonstration was not possible because much of the data were unavailable. Since the Demonstration consisted of very costly, hand-made, high-maintenance prototype vehicles and infrastructure and one user per vehicle each day—a situation that would not occur in the future—detailed analysis would not be particularly informative to those planning future station car programs. However, data on participants' willingness to pay were collected and the results are presented in this section. Data available relative to vehicle operating and maintenance costs are also presented, as is the revenue potential of station cars to BART.

Lease Amounts Participants Were Willing to Pay

The original program design was to have BART and PG&E employees pay $100/month for use of a station car, with emphasis on carpools (in which the monthly lease would also be shared). When Sybase entered the program, the company paid the monthly leases of $100 for each CITI. When the program ended, no Sybase employees opted to continue at their own expense. At that time, the monthly leasing rate was raised to $150 for home-end use. This rate was used for the BofA employees, with BofA paying half the cost. BART employees who used the CITIs at the work-end Colma Station were charged $100/month. In March 1997, cars were offered to the general public at a monthly rate of $250, with no takers. The rate was varied between $100 for a work-end lease and $200 for home-end use.

Table 18 presents the numbers for each leasing rate, descriptions of drivers, and when drivers entered the program. Forty-nine percent of the cars were leased for $95-$125/month; 41% for $150/month; and 10% for $200/month. Note that the total number of leases was 63 (less than the number of participants) because some people split the lease cost and carpooled.

While participants were still driving the CITIs, they were asked what they would be willing to pay for a station car at the home-end, the work-end, and both home- and work-ends. They were also given the American Automobile Association's estimate for the fully-loaded monthly cost of owning a vehicle, which was $450. The amounts people were willing to pay to continue using station cars are shown in Table 19.

As shown in Figure 23, based on responses from 22 people, there were five groups: those who would not pay more than $100 per month; a group that was willing to pay $100; those willing to pay $200; a group that varied its willingness-to-pay between $100 and $200; and a fifth group that valued station cars at around $300. Willingness-to-pay to continue using a station car was compared to current lease amounts.

Table 17. Lease Rates

Monthly Leasing Rate	Number of Leases	Number of Cars Used	Entry Date
$200	6	All general public	May/June 1997
$150	26	8 BofA paid half 7 BART & PG&E employees 8 general public 3 paid by CFI for Alameda	August 1996 Various March 1997 January 1998
$125	1	BART employee	April 1997
$108	1	PG&E employee	October 1996
$100	26	9 paid for by Sybase 9 BART employees 1 BART employee spouse 3 BART pool cars 1 CALSTART employee 1 Berkeley electric shuttle employee 2 general public	November 1995 Various May 1997 November 1995 March 1997 March 1997 May 1997
$95	3	1 BART 2 general public	June-August 1997 March 1997
Total	**63**		

Table 18. Amount Participants Were Willing to Pay per Week for Continued Use of Station Cars

	Continue "as is" in the Demonstration	Continue"as is" and If-Give Up a Car	Both Work and Home Ends
Average	$55.28	$65.09	$61.18
Maximum	$200.00	$200.00	$250.00
Minimum	$10.00	$25.00	$10.00

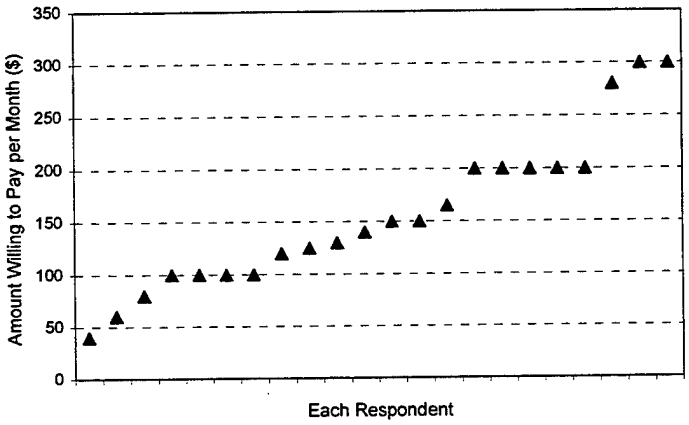


Figure 23. Amount People Were Willing to Pay to Continue Leasing a Station Car

Figure 24 shows the difference between current lease amounts and how much more people were willing to pay to continue using a station car. In all cases where two people shared the lease amount, they were willing to pay as much as $200 more per month ($100 each). Clearly, the majority of respondents were happy with the current lease amount, with over half wishing to continue at the same or slightly higher level. Again, there were two groups at both tails of the curve, willing to pay either considerably more or considerably less.

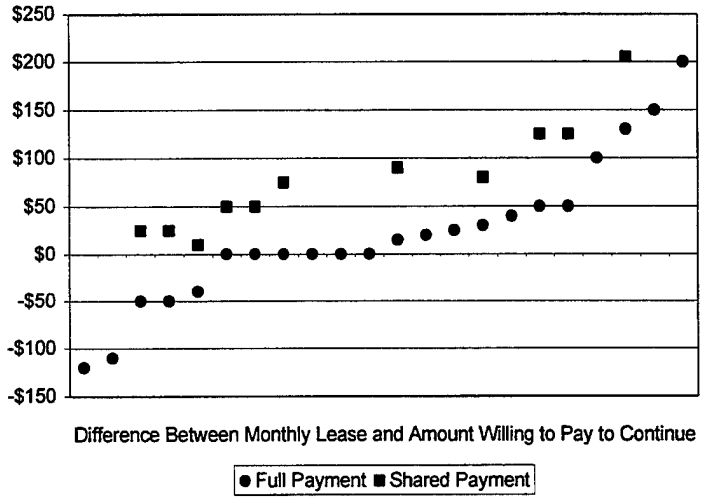


Figure 24. Additional Amount Willing to Pay per Month, Depending on Whether Cars and Leases were Shared

A willingness-to-pay issue to address in future demonstrations, and more systematically through research, is the perceived difference between the station car as a "product" or as a "service." When perceived as a product, the potential user considers a monthly leasing cost over a long period of time; when perceived as a service, the potential user considers a daily—or even hourly—cost.

Vehicle Operating and Maintenance Costs

BART paid an average of 8¢/kWh for station power during the Demonstration. (It now pays less because it buys power from alternative suppliers.) At 0.34 average kWh/mi for the CITIs, the cost of electricity was 2.72¢/mi. With optimized vehicles, that would drop to less than 1¢/mi. Gasoline at $1.39/gal would result in an energy cost of 6.4¢/mi for the typical ICE used in this analysis.

Vehicle maintenance costs are difficult to estimate because they are considered proprietary and records are not available. The vehicles were covered under PIVCO's warrantee for the Demonstration, thus PIVCO supplied parts at no charge. GMW estimated that during the Sybase portion of the Demonstration, they employed two FTEs—50% for administration and 50% for warranty repairs. During the transition

from 12 to 38 cars (August 1996 through March 1997), GMW estimated 3.5 FTEs and also during that time PIVCO had 3 FTEs in Alameda for about 2.5 months. After that through March 1998, GMW employed 3 FTEs. Beginning in February 1997 and through March 1998, PIVCO paid for 1.5 of the FTEs since GMW convinced PIVCO that the warrantee repairs were so time-consuming that GMW could not pay the resulting wages. Administration has always stayed at about 1.0 FTE. Needless-to-say, 2 to 2.5 FTEs to keep 38 cars in the field is excessive and, due to the prototypical nature of the CITIs, maintenance costs of these vehicles are not applicable to future station cars.

Revenue Potential

The additional passenger miles on BART by participants in the Demonstration represented $18,464 in fares. In the "10,000 Station Cars" scenario, the additional revenue would be $32.8 million. Since half of these revenues would come from reverse commuters riding trains that would run anyway without this added ridership, $16.4 million would be revenue gained without costs.

SECTION 9. CONCLUSIONS AND LESSONS LEARNED

Conclusions

The purpose of the Demonstration was to determine the viability of EVs for making short, everyday trips in a variety of settings—home to BART station; BART station to work site; and pool cars for work sites. This goal was met. The Demonstration showed that non-technical people have no difficulty driving EVs on a daily basis or understanding the station-car concept.

Clearly, better EV technology is required to make the concept work. Also, to make the concept economical from a household's point of view, station cars must be used by multiple users each day and electronics are necessary to reduce the labor cost of providing the service. The electronics would do reservations, vehicle access, billing, vehicle tracking, etc.

While the recharging infrastructure was overbuilt, the 40 charging ports at BART stations offer an opportunity to further test the station car concept with larger numbers of EVs. Recruiting from the general public turned out to be difficult, especially because the Ashby Station (which had the most infrastructure and thus required the most participants) was rarely anyone's first choice. A better method is that used by the New Jersey demonstration, which recruited *only* from corporations during its demonstration stage, and which was most successful in the Bay Area Demonstration.

Mobility is key to the operation and financial survival of a household. Changing mobility habits is not easy and having a good mobility concept is insufficient by itself. A program that people perceive as permanent is critical to obtaining significant participation. Stated differently, changing long-term commute habits in a short-term program is not worthwhile for most people. Why should they give up owning one household car to save money when they know the program will end?

A most important conclusion is that the Demonstration took BART and others far along the station-car learning curve. It has been the starting point for demonstrations elsewhere and it set the stage for more complex multiple-user demonstrations as the next step in commercializing the concept.

Even this imperfect demonstration had many positive benefits. The environmental benefits were small because the Demonstration was small. The response from the drivers and the general public was clear—people "love" the idea and "love" small functional EVs. From transit's point of view, the ridership, parking, and land-use (TOD) aspects of station cars may be the greatest benefit. Certainly, it will be a primary goal of an expanded program.

Increased awareness of EVs by the general public, the potential impact on the EV industry, lessons learned about the station-car concept, and the station-car momentum that exists within and outside BART comprise the true legacy of the Demon-

stration. All this exists because of 40 red, green, and blue plastic/aluminum EVs, plus the vision and dedication of the stakeholders—a plastics company, the sponsors, the service provider, key BART staff, and two private corporations—and, of course, the participants who were out there, day after day, demonstrating the concept and showing off their EVs.

Lessons Learned

The lessons learned are grouped by Demonstration components (impacts, management, operations, vehicles, and participants).

Impacts

1. The Demonstration had many positive impacts, including environmental, energy, congestion, social, educational, and financial (BART revenues).

2. The scenarios described in Section 4, which remove the imperfections and increase the size of the Demonstration, show the potential that station cars have to greatly increase these benefits, including the extremely important benefit of reducing the amount of land required for parking and allowing the land to be available for more productive use. The "10,000 station cars" scenario results show that the station car concept could have the potential of improving the transportation related problems in the Bay Area during the first decade of the next century, especially if the concept is extended to other Bay Area rail systems, ferries, and some express bus routes.

3. The non-quantifiable benefits, many of which were not even considered at the outset, are undoubtedly the most important and long lasting results of the Demonstration.

Management

1. Based on this and other station car demonstrations around the country, a project "champion" is essential. In this project, the champion was the BART Station Car Demonstration Project Manager. The champion must be able to devote full time to the demonstration during its planning and implementation, must have significant organizational support, and must have significant flexibility within the organization. Every day, there are new decisions to be made. An inflexible bureaucracy would probably make implementation impossible.

2. During planning and implementation, cooperation between and the joint effort of PG&E and BART was essential, especially in infrastructure development and installation.

3. Sponsors must be flexible. The actual Demonstration and the one that was planned five years ago differ considerably. Sponsors must be able to accept mid-course adjustments; the flexible working relationship among all the stakeholders

is what kept the Demonstration alive at a few crucial times. BAAQMD and CALSTART participated in and agreed to all major adjustments to the Demonstration.

4. The champion must have a small team to brainstorm with on a regular basis. Whenever there is a problem without an obvious solution, brainstorming is needed to help create alternatives and decide how to proceed to a solution. This probably happened over a hundred times during the planning, implementation, and operation of the Demonstration.

5. The data collected were not as robust as originally anticipated. More resources need to be spent on data collection. It has to be someone's primary job, probably the person who recruits, trains, and otherwise interacts with participants.

6. A guest book should be kept to document interest and diffusion of ideas. At the outset of the Demonstration, no one realized that so many national and international interested parties would visit. The lists of visitors given in Section 2 had to be recreated and thus reflect only a portion of the on-site attention the Demonstration received.

Operations

1. A program such as this requires a service provider with staff who can interact well with the participants, plus technical staff to maintain the fleet. Clearly, two types of skills are needed to perform these two different tasks. It is rare that one person would have both. For the early part of the Demonstration, GMW hired a personable young man to interact with the drivers. However, he was unable to address difficulties with the vehicles, since he was neither a mechanic nor an electrician. If GMW had not hired a fleet manager with extensive mechanical/electrical experience when it did, the Demonstration would have failed because cars would not have been available.

2. Too much infrastructure was installed. The assumption was that each car needed a charging port. The fact is that the cars spent significant time away from the station. The Ashby Station facilities provide the best example. Nineteen charging ports and a transformer sized to supply all 19 at once were installed. Never were more than 12 cars assigned to Ashby Station at one time, and it is likely that never more than 6 were there at the same time. Even then, often only one was plugged in, and it was probably unusual for more than three to be plugged in at once. Depending on the station, two to five times too much infrastructure was installed. This is a two-sided lesson: the second part is that station cars were away from the station a good part of the time, as they should be, serving participants' trips.

3. Ashby Station was a poor choice because it is so close to two other stations that had better station-car attributes (North Berkeley and Rockridge—both have oversubscribed parking and are attractive to more "ideal" participants), thus access and egress trips were short and the amounts people were willing to pay for

station cars was low. Ashby Station was chosen because of what was initially a strong interest by the City of Emeryville in station cars. However, this interest waned with its loss of funding, so GMW was left without participants to make use of the infrastructure.

Vehicles

1. When they were in good running order, the CITIs performed the station car mission quite satisfactorily. Two BofA employees drove their cars for 19 months each, home-end, from Ashby Station.

2. Given all the limitations of the CITIs, the participants "loved" them and gave them names. If a person's assigned CITI was taken in for routine maintenance, he/she wanted the same one back. This lesson is positive if single-users for long periods of time are wanted; it may be negative, though, if a program is focused on multiple users each day.

3. Because of the unique look of the CITI, participants spent considerable amounts of time explaining what they were to passersby. In one Berkeley parade, the group of 15 CITIs was given ovation after ovation.

4. Having retractable cords in the noses of the cars and simple connections were excellent specifications.

5. Use only ground-up built EVs that have been thoroughly field-tested. The prototype CITIs required tremendous care. During the latter part of the Demonstration, six cars had to be addressed each day. Most problems could be fixed in the field, yet a few cars a week had to be brought back to the shop. The manufacturer be involved in maintenance and have a spare parts inventory near the Demonstration. Waiting for spare parts and engineering support caused many car months of no service. Conversely, it must be remembered that the CITIs were the only ground-up built and appropriate EVs available in the mid-1990s. Their availability allowed the Demonstration to go forward and prove its positive impacts.

6. Do not use untested technology, especially in conjunction with prototype cars. This refers both to failed attempts to have an automated kiosk for recharging at Walnut Creek Station and to the inability to satisfactorily retrofit eight CITIs with air conditioning. The kiosk problem was due to under-developed technology and the air conditioning failure was due to a systems integration problem.

7. The request for proposals for the turnkey service provider stated the amount of funds available and the number of cars and types of services desired. U.S. Electicar bid those specifications. With hindsight, it is obvious that they severely underbid. This, along with problems with their technology, led to their request to substitute a less costly, unacceptable vehicle. The lesson here is, if you get too low a bid, the deal is likely to fall through. Fortunately, U.S. Electricar realized its error before entering the contract and before BART appropriated funds.

8. When you put cars out in the real world, there are going to be real-world problems. There were a few traffic accidents, and some vandalism at the Ashby Station and to cars parked on streets overnight.

Participants

1. The participants were true innovators, either because they were fascinated by the EV technology or because they placed a high value on improving the environment.

2. Do not depend on only two firms to provide all participants. BART and PG&E failed to provide 20 participants each, causing several car months of driveable cars waiting for drivers.

3. Recruitment from the general public is best done through corporations that can appoint a company liaison to identify participants and collect data. The company can find people who are currently making all-ICE commutes and then often can subsidize the new all-electric commute. Often, the company can claim credit for traffic reduction efforts.

4. People are willing to pay for station car use for a variety of very specific conditions, but the amount does not appear to correlate with specific groups of reasons. The station car is greatest value, however, to people who really want to avoid long commutes by ICE car.

5. Further research is needed to distinguish if there is a perceived difference between the station car as a "product" versus the station car as a "service." When perceived as a product, the potential user considers the value of a monthly leasing cost over a long period of time; when perceived as a service, the potential user considers the value a daily—or even hourly—cost.

6. Demonstration participants are the best ambassadors of the program and their enthusiasm easily spreads far beyond the reach of traditional advertising.

7. Frustration with BART service (location of stations with infrastructure, timing of trains, need for transfers, cost of fares) caused several users to drop out of the program.

8. People do not always use the station cars in accordance with the program's design and intention. For example, some drivers were parking at other stations and charging at home, even though they had free charging at the designated stations. The drivers were told not to drive on the freeway, but one reported freeway trips in his "during" trip log.

Participants' Opinions about the Demonstration

At the end of the Demonstration, however, it is the participants' overall experience with electric station cars and the program that testify to its success. Their comments, when asked if the program met their expectations, suffice to make this point:

- *Yes! (4)*
- *Yes. Car performance is better than I expected and the bonus of a reserved place at BART was irresistible.*
- *Yes, other than poor reliability.*
- *Yes. I would have loved to try other cars.*
- *Yes, except for the range and not being able to drive on the freeway.*
- *Within the limits of the program, all of my expectations were met.*
- *Generally, very well. I still have to get in touch with someone who reads Norwegian to translate the Lars Saethre article from last October! Afterposten from Oslo! Keep me in mind in the future if newer electric cars become available.*
- *Yes. I reduced the use of my gas car.*
- *Yes. It's been fun explaining the station car to spectators and I feel good driving a car that gives off no emissions.*
- *Yes—wanted to move toward electric car.*
- *I expected in off-freeway driving to get fairly directly to all places within the car's range. The Caldecott Tunnel prevents much of that access. I expected a dry interior in rain.*
- *Yes. It's almost an example of how Ford must have felt putting out its car. It took a lot of tests to get it right.*
- *Somewhat. I think the BART demo project was a good first phase project. Better vehicles would sell the public on concept better. Good initial program . . .*
- *Yes. Station cars are very convenient and make the BART experience enjoyable.*
- *Yes. Project has been fun. Many people I meet are enthusiastic.*
- *Yes, except suspension of vehicle was not good—vehicle does not do well over speed bumps and even small dips in even main road.*
- *Yes, if we have to sit in traffic. I don't want to breathe fumes from nearby cars.*
- *Yes. I know just by the fact of being seen, I have made people think. Not to mention the PIVCO exceeded my expectations in almost every way.*
- *Yup. I got to experience owning an e-car for round-town driving—it works!*

The Last Words

At the conclusion of the field test, the first 12 CITIs were exported back to Norway (see Figure 25). Since they were in the country on FMVSS waivers, they either had to be crushed or exported. Four cars fit in one 40-foot freight container. Shipping took four to five weeks and cost about $3,000 per container.

Figure 25. After 2½ years of Service, One of the First 12 CITIs (with its Export Papers) in a Container Ready to be Shipped back to Norway in April 1998

APPENDIX A
REPORTS AND STUDIES

"Alternatives to Car Ownership," *Innovation Briefs*, Vol. 7, No. 4. Urban Mobility Corporation, Washington, D.C. August 1996.

BART Customer and Performance Research. "Station Car Market Assessment: Scope of Work and Funding Proposal." October 9, 1996.

Bernard, Nerenberg, and Collins. "Environmental and Energy Impacts of the San Francisco Bay Area EV Station Car Demonstration: November 1995 - March 1998." EVS-15, Brussels, Belgium. October 1-3, 1998.

Bosselmann, Cullinane, Garrison, and Maxey. "Small Cars in Neighborhoods." PATH Research Report, Institute of Transportation Studies, University of California, Berkeley. 1993.

Cervero, Round, Reed, and Clark. "The All-Electric Commute: An Assessment of the Market Potential for Electric Cars in the San Francisco Bay Area." Institute of Transportation Studies, University of California, Davis. 1994

Collins, Bernard, and Meurer. "Understanding Driver Recruitment Issues in the San Francisco Bay Area EV Station Demonstration." EVS-15, Brussels, Belgium. October 1-3, 1998.

Jennings, Beliso, and Pfieffer. "Load Impacts of the Colma BART Station Cars." *Proceedings*, EVS-14, Orlando, December 14-17, 1998.

"The Journey-to-Work in the San Francisco Bay Area." Working Paper #5. Metropolitan Transportation Commission, Planning Section. 1993.

Nerenberg. "Station Cars with the Bay Area Rapid Transit." Automatic Car Rental, Car Sharing, and Car Pooling Colloque, Paris, June 2, 1997.

Nerenberg. "The Bay Area Station Car Demonstration." 76th Annual Meeting, Transportation Research Board, Washington, January 12-16, 1997.

Nerenberg and Bernard. "Station Cars: Personal Mobility at Less Dollar and Social Cost." *Proceedings*, EVS-14, Orlando, December 14-17, 1998.

Round. "Implementing the Emeryville Station Car Program: Structure, Initial Travel Findings, and Future Growth." Institute of Urban and Regional Development, University of California, Berkeley. May 1996.

Shaheen and Nerenberg. "Smart-Car-Sharing Markets in San Francisco Bay Area: Study of Behavioral Adaptation." 77th Annual Meeting, Transportation Research Board, Washington, January 11-15, 1998.

Shaheen, Sperling, and Nerenberg. "Smart Car Linking in the San Francisco Bay Area: A Market Evaluation." Eighth Annual Meeting of the Intelligent Transportation Society of America, Detroit, Michigan, May 4-7, 1998.

Spiekerman and Weinstein. "Evaluation of the Potential Commuter Market for Station Car Usage at the Bay Area Rapid Transit District." 77th Annual Meeting, Transportation Research Board, Washington, January 11-15, 1998.

APPENDIX B
EXCERPT FROM NEWS ITEM DESCRIBING THE 1971 STUDY PROPOSING STATION CARS

Thursday, May 13, 1971

30,000 Minicars For BART Riders?

MARTINEZ — Picture a fleet of 30,000 electric minicars flitting about central Contra Costa county, carrying rapid transit passengers to and from stations.

Add a dial-a-bus system that allows elderly persons in north and central Contra Costa to telephone for a 28-passenger vehicle as if it were a taxi.

And maybe the most outlandish of all — conventional buses serving Antioch and Martinez, where there has long been a lack of public transportation.

The scene was described to the Contra Costa County Board of Supervisors yesterday by the staff of a consulting engineering firm hired to study methods of providing rapid transit feeder service and public transportation in the county.

The small, electric cars — one was on display outside the county administration building — drew the most attention and James Schmidt, project manager for Deleuw, Cather & Co., the San Francisco firm which did the $150,000 study, asked supervisors to endorse a federal experiment with the cars in Contra Costa county.

Supervisors, however, referred the entire report to their administration and finance committee, the county administrator and the county public works department for future study.

The publicly-owned minicars will appeal to persons who normally drive, Schmidt told supervisors.

He envisioned a system in which a resident may pick up one of the cars at a curb stand located within a block or so of his home and then drive it off by inserting a previously-obtained credit card which in turn causes a key to be dispensed.

Designed for short trips of some two-and-a-half miles, the electric cars, which would go no faster than about 35 miles an hour, would then be dropped off at another curb stand, probably at a BART station.

Later in the day the same commuter would pick up another electric car at the BART station and scoot on home.

Each time the credit card is inserted a computer will record the use of the car for billing at the end of the month, Schmidt said. He estimated cost at about seven cents a mile.

Schmidt said that curb stands containing about five cars could be located throughout the central county so that everyone would be within walking distance of an electric car.

After rush hours the cars would be linked up in trains and towed back to curb stands so that one is always available, he said.

The system initially would cost about $70 million, Schmidt said. It could be financed by both the rental revenues and by issuing bonds, he said.

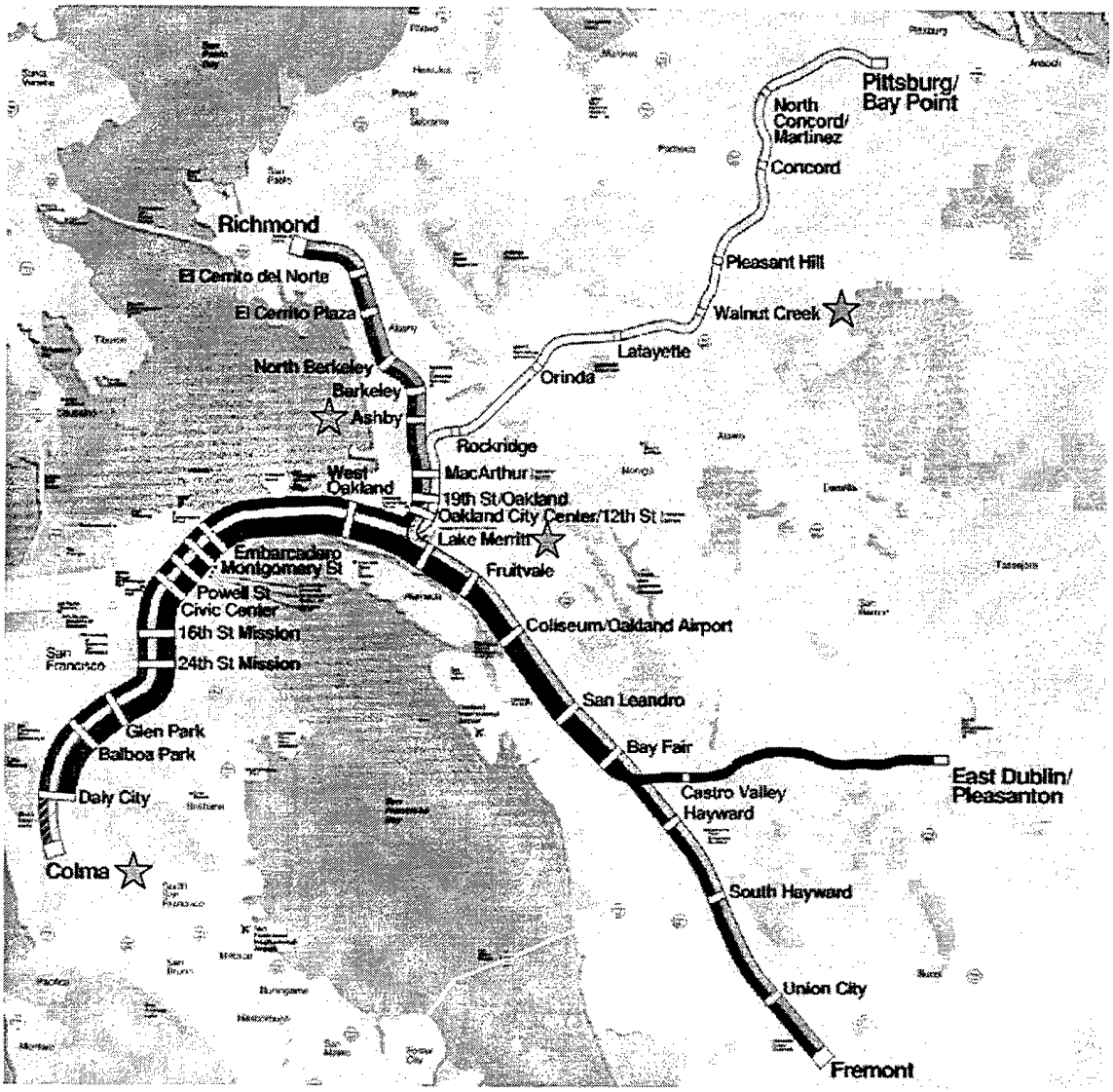
Schmidt contended that a fleet of 30,000 electric minicars would replace 60,000 "second" cars in Contra Costa county.

[more . . .]

APPENDIX C
KEY PEOPLE INVOLVED IN THE DEMONSTRATION

Key Person	Organization	Role
Lead Agency		
Victoria Nerenberg	BART	Project Manager; Coined "Station Car"
Mark Pfieffer	BART	Infrastructure Manager
Aaron Weinstein	BART	Proposed Initial Concept, circa 1990
Rolf Sabye	BART	Royal Inauguration Manager
Funding Sponsors		
Thomas Addison	BAAQMD[a]	Technical Advisor
Irene Salazar	CEC	Technical Advisor
John Boesel	CALSTART[a]	Technical Advisor
Kent Harris	PG&E[a]	Technical Advisor, Recruit Participants
Alan Schurr	PG&E	Wrote Original Funding Proposal
Al Beliso	PG&E	Responsible for Infrastructure
Service Provider		
William Meurer	Green Motorworks	President
Brian Clark	Green Motorworks	First Operations Manager (9 cars)
Robert Reese	Green Motorworks	Second Operations Manager (40 cars)
Vehicle Provider		
Jan Otto Ringdal	PIVCO	CEO
Others		
Irma Rivera	Bank of America	Recruit Participants
Neal DeSnoo	City of Berkeley	Multiple-user Experiment, Pool Cars at Worksites
Karen Hemphill	City of Emeryville	City Liaison
Allison Richards-Evensen	CF International	Planned and Managed Alameda Hospital Multiple-user Experiment
Martin Bernard	NSCA	Consultant and Project Evaluation
Richard Lu	NSCA	Intern assigned to BART
Alfred Round	National Transit Access Center, U.C. Berkeley	Data Collection and Analysis During Sybase Portion of Demonstration
Jan-Erik Haried	Norwegian Industry Attaché Office, San Francisco[a]	Technical Advisor
Timothy Hussey	Sybase	Station Car Participant Coordinator

[a] This organization assigned two or more advisors during the planning and implementation of the Demonstration. The person listed was the advisor at the end of the Demonstration.



The Stars Indicate Stations with Recharging Infrastructure During the Demonstration